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**Using Geographic Information Systems to Identify Habitat for the Golden-winged
Warbler (*Vermivora chrysoptera*) in Western New York**

by

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of
Science in Environmental Science

College of Science
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September 20, 2016

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ABSTRACT

The Golden-winged Warbler (*Vermivora chrysoptera*) is a passerine species whose populations have decreased internationally by approximately 66 percent since the 1960s, and by approximately 50 percent in New York. Major causes for declines are from loss of shrubland habitat and through hybridization with the Blue-winged Warbler (*Vermivora cyanoptera*). This study utilized published data and expert opinion on Golden-winged Warbler (GWWA) habitat requirements to create habitat suitability models within the Western Finger Lakes Region of NY (NYSDEC Region 8) using a geographic information system. This region is an important area for migratory birds and is previously unstudied for GWWA. The concentration of potential GWWA habitat was identified within the central part of the study area, dubbed the “Central Band”, comprising of areas within Livingston, Ontario, Schuyler, Seneca, Steuben, and Yates Counties. Sighting data from the Breeding Bird Survey (BBS) and Cornell Lab of Ornithology’s eBird Program (eBird) were utilized to test for the presence of GWWA within predicted habitat sites. BBS data were useful as an indicator of the model’s effectiveness, with two-thirds of BBS routes containing GWWA sightings intersecting predicted prime habitat sites. Cornell’s eBird sighting data were less effective as an indicator of the model’s accuracy, as available eBird data may contain spatial bias through under-reporting by fewer birders in areas of high habitat concentrations. This study also analyzed proximity of GWWA habitat to public and privately managed lands, offering specific locations where GWWA conservation plans, like NYSDEC’s Young Tree Initiative, could effectively be implemented with a focus on breeding bird habitat. GWWA habitat conservation is significant, as their habitat is also utilized by other species of conservation concern, such as American Woodcock (*Scolopax minor*) and Ruffed Grouse (*Bonasa umbellus*), making GWWA a type of umbrella species within early successional habitat.

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INTRODUCTION

Trends in Avian Populations and Shrubland Birds

Internationally, avian populations in a majority of habitats are decreasing (Crosby et al., 2015; Jenouvrier, 2013). In the United States, over one-third of the native bird species are listed as endangered, threatened, or of conservation concern, and habitat loss is a primary reason (Environment and Climate Change Canada, 2016). Birds are not the only species negatively affected by loss of habitat, as decreases in habitat can impact species in all ecosystems, leading to an overall loss in biodiversity (Cardinale, 2012; Reich et al., 2012).

Shrubland birds are one avian group being threatened by habitat loss (Crosby et al., 2015; Lehnen and Rodewald, 2009). A 2014 report sponsored by the North American Breeding Bird Survey, the United States Department of Interior, and other conservation agencies suggests that shrubland birds in North America have experienced population declines of approximately 46% since 1968 (U.S. Department of Interior, 2014). These declines over the last half century can be partly attributed to loss of early successional habitat from urban development and lack of land management practices, such as selective clear cutting and prescribed fires, which have consequently allowed these habitats to develop into mature forests more ideal for woodland species (Sauer et al., 2014; Roth et al., 2012; Confer, 2011).

Historically, aside from natural causes like fire, wind, and beavers (*Castor canadensis*), some early successional habitats in parts of the United States have also relied on anthropogenic causes to help them regenerate (DeGraaf and Yamasaki, 2003). This includes farming practices of indigenous peoples, European settlers, and clear cutting of timber when it was a more popular fuel source (Brooks, 2003). Because of their reliance on disturbance, shrublands are among the

rarest habitat types in the United States, making them an important ecosystem for conservation efforts (DeGraaf and Yamasaki, 2003).

Shrubland History in the Northeast

In the Northeast United States, shrublands were likely uncommon before European settlers (Foster and Motzkin, 2003), but developed from abandoned farmlands that have undergone secondary succession (Sauer et al., 2014; Hunter et al., 2001). Northeastern shrublands remain important, however, because they provide habitat for many declining animal species, and also contain a high proportion of rare plants compared to other shrubland areas within the United States (DeGraaf and Yamasaki, 2003). In the beginning of the 19th century, agriculture lands of the European settlers became more prominent in the New York, New England, and other areas of the Northeastern United States (Bullock et al., 2013; Confer, 2011). By the mid-19th century, however, farmlands in these areas were lost as industrial cities grew, more efficient farmlands outside of the Northeast developed, and transportation of produce and goods become more efficient (i.e. Erie Canal); all of which made it easier to get food and supplies into the cities (DeGraaf et al., 2006; Brooks, 2003; Oehler, 2003). These factors led to an increase in abandoned farmlands as people moved to urban centers, which consequentially led to an increase in early successional habitat, as vegetation reclaimed the abandoned fields (Bullock et al., 2013; Confer, 2011). Subsequently, another period of farm abandonments occurred in the 1930s as a result of the Great Depression (Brooks, 2003; Lorimer, 2001). These were periods of shrubland peaks.

Beginning in the 1950s, there has been a significant decrease in shrublands, mainly from maturation of forests and lack of natural disturbances (Brooks, 2003). This decrease has also

caused a decrease in animal populations that rely on early successional habitat (DeGraaf and Yamasaki, 2003). This includes shrubland birds like the Golden-winged Warbler (*Vermivora chrysoptera* – hereafter referred to as GWWA), a species that has experienced population declines throughout their range from habitat loss (Bullock et al., 2013; Confer et al., 2011).

Golden-winged Warbler

Golden-winged Warbler is a near-threatened species whose populations have decreased internationally by approximately two-thirds since 1966, and whose populations are estimated at approximately 410,000 (Sauer et al., 2014; Roth et al., 2012). They are currently being considered for listing under the Endangered Species Act (Bakermans et al., 2015; Sewell, 2010). Since the late 19th century, GWWA population reductions have occurred most drastically in their southern breeding territories in the United States; in part from suppression of prescribed and natural fires, which allowed mature forests to develop in former shrubland areas (Bakermans et al., 2011; Confer, 2011; Confer et al., 2003; Gill, 1980). In New York State, the population has decreased by approximately 53% in the last three decades (Confer et al., 2010; Confer, 2008). Major reasons for population declines in New York are from shrubland habitat loss, hybridization/competition with the Blue-winged Warbler (*Vermivora cyanoptera* – hereafter referred to as BWWA), and to a lesser degree nest parasitism from the Brown-headed Cowbird (*Molothrus ater*) (Bullock et al., 2013; Confer et al., 2010; Bullock et al., 2007).

Physical Description

The Golden-winged Warbler is a small neotropical migratory passerine, whose males (Figure 1) are described as an overall grayish color with a bold yellow crown, and a dark black

mask and throat (Sibley, 2014). A typical GWWA is about thirteen centimeters in length, with a wingspan of nineteen centimeters, and weighs less than nine grams (Sibley, 2014; Confer, 2011).



Figure 1. Male Golden-winged Warbler (Wood, 2010), (<https://www.flickr.com/photos/pinicola/4711030154>).

Range

Presently, GWWA eastern breeding grounds in North America spans from Georgia up to New York and Massachusetts. Its western breeding territory runs through Michigan, Minnesota, and Wisconsin, and continues up to Ontario, Quebec, and Manitoba, where it is listed as a threatened species (Bullock et al., 2013; Roth et al., 2012; Buehler et al., 2007). Eggs are laid in the first weeks of May, and males typically arrive a week prior to scout territory. Most hatch

year birds begin heading back to their southern wintering grounds in Central America and South America by mid-July (Confer, 2011). Figure 2 shows a composite map of GWWA ranges (NYSDEC, 2009a).

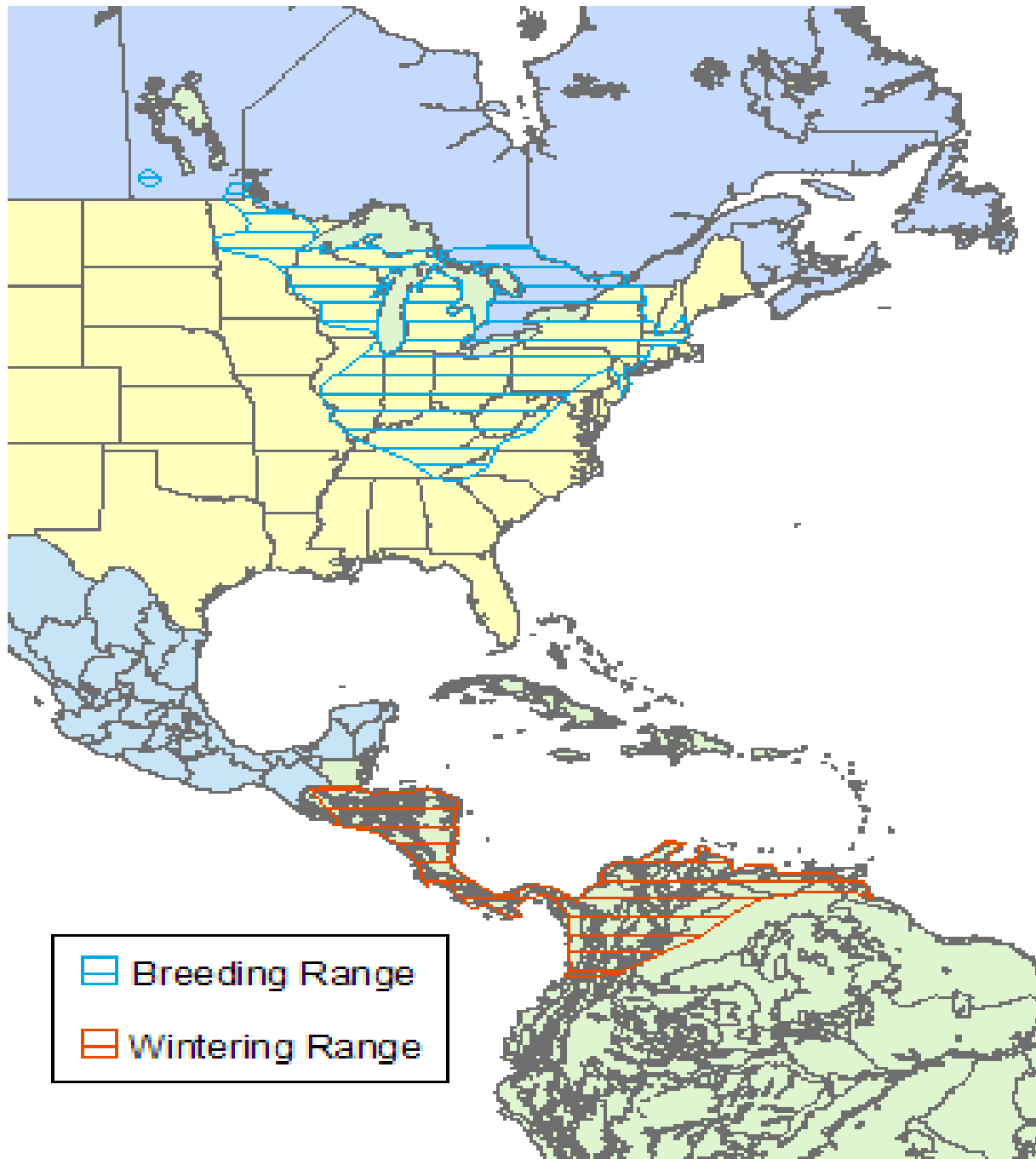


Figure 2. Range for GWWA. Accessed from the Golden-winged Warbler Fact Sheet (NYSDEC, 2009a). (<http://www.dec.ny.gov/animals/59568.html>).
History in New York.

GWWA were first reported in New York sometime in the mid-1800s (Confer, 2011). During this time there were small numbers of GWWA sparsely distributed in the south and central regions of New York. As abandon farmlands in New York turned into shrublands, GWWA began to move northward from the southern states at a rate of 6.4 km per year during the 1900's (Bullock et al., 2013). The New York population increased until the late 1970's, but since that time the population has decreased by approximately 53% (Confer, 2010; Confer, 2008). This decrease coincided with the northeast expansion of BWWA, who often outcompete GWWA throughout their breeding range, and also the loss of early successional habitat (Confer, 2011). Figure 3, from the Breeding Bird Survey Atlas (NYSDEC, 2007a; NYSDEC, 2007b), a program aimed at estimating population trends of bird species that breed in North America (Butcher et al., 1993), show that GWWA sightings throughout New York have decreased since the 1980s. This can be seen in the Western part of New York, specifically the Finger Lakes Area, which is the focus area of this study.

Hybridization with Blue-winged Warbler.

In addition to habitat loss, a compounding factor in reducing GWWA populations in New York, as well as most other states in their range, is hybridization and competition with the Blue-winged Warbler (*Vermivora cyanoptera*) (Bullock et al., 2013; Confer et al., 2010). BWWA expanded into GWWA's southern breeding territory during the 19th century, where it has out-competed GWWA (Roth et al., 2012; Confer, 2011). Currently, in neighboring areas such as Massachusetts, where BWWA are more common but share habitat with GWWA, the Golden-winged Warbler populations have nearly been reduced to zero (Confer, 2003). Figure 4, from the Breeding Bird Atlas (NYSDEC, 2007a; NYSDEC, 2007b) shows how the numbers of

BWWA have changed in New York overtime, showing a trend in movement north into the St. Lawrence Valley (NYSDEC, 2009b), where the largest populations of New York's GWWA reside (Confer, 2011).

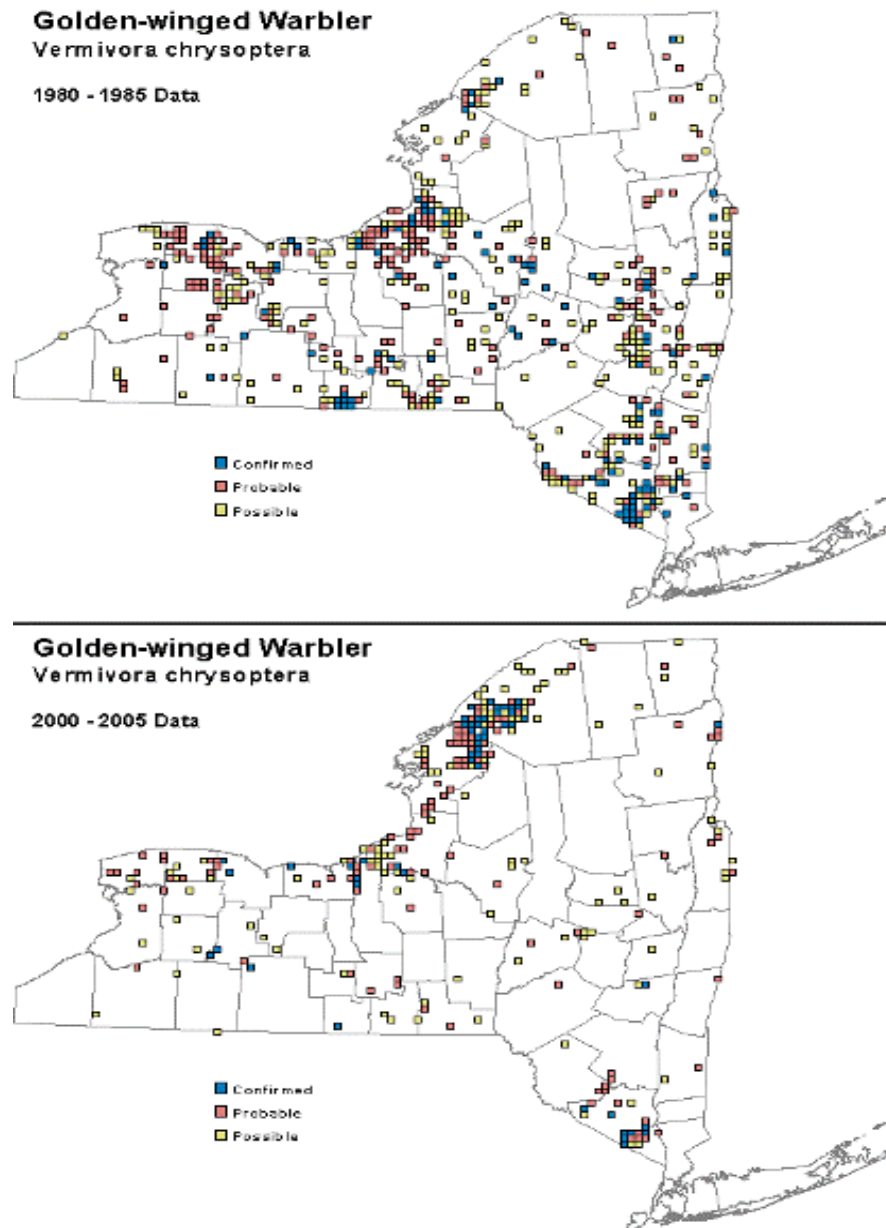


Figure 3. BBA sightings for GWWA decreasing in NY (<http://www.dec.ny.gov/animals/59568.html>).

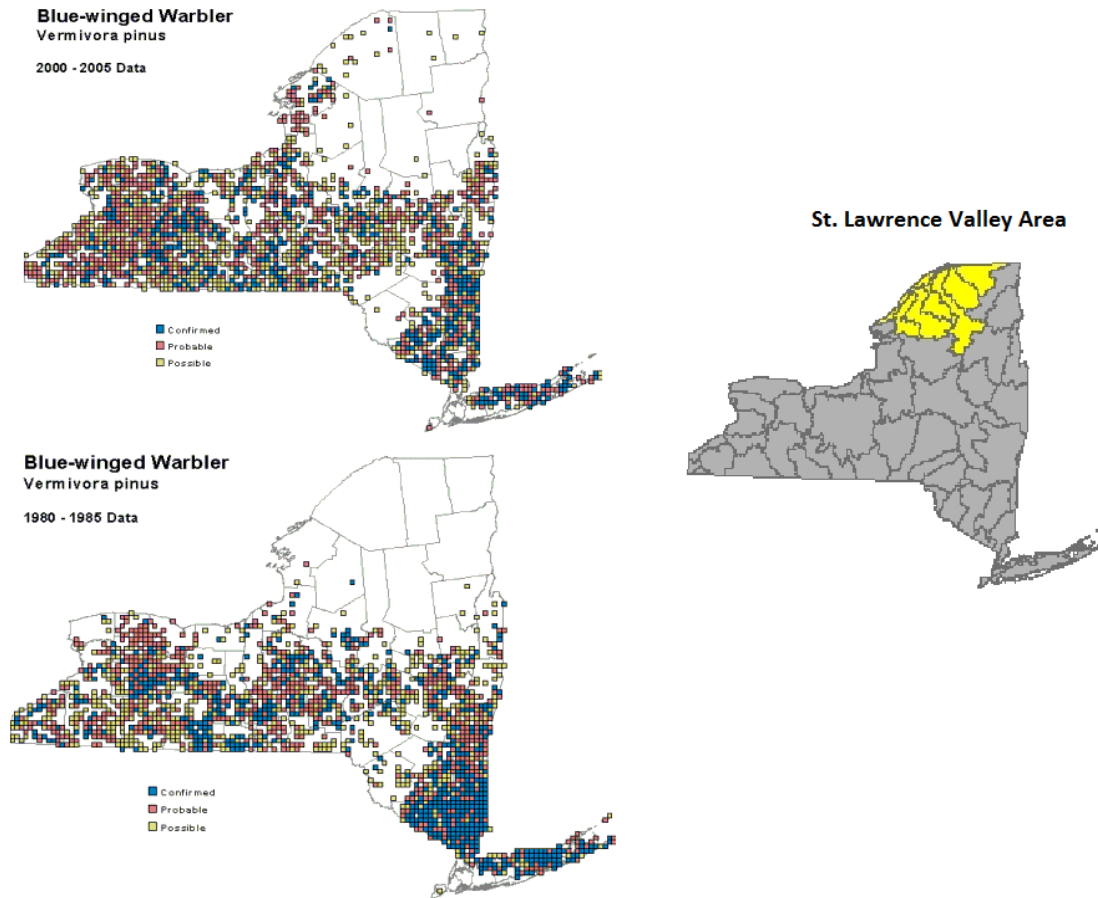


Figure 4. *Left:* Breeding Bird Atlas sightings for BWWA in New York over time (http://nm.audubon.org/sitess/default/files/documents/hrvc_bluewingedwarbler.pdf). *Right:* St. Lawrence Valley Area (NYSDEC, 2009b) (<http://www.dec.ny.gov/chemical/36735.html#Assessment>).

In New York, as BWWA populations continue to increase and GWWA habitat decreases, GWWA are predicted to continue moving northward into Canada, Minnesota, and northern New York in an effort to find new territory (Bakermans et al., 2011; Confer, 2011; Gill, 2004). Due to their constant northern movement, the GWWA has been dubbed a fugitive species (Gill, 2004; Gill, 1980). Figure 5 (Sauer et al., 2014) shows how GWWA populations are increasing by 1.5% per year (blue) in the northern United States and into Canada, and decreasing in the southern United States and the Northeast by approximately 1.5% per year (red). This graph suggests that the species is moving northward as Gill described.

BBS Trend Map, 1966 - 2013

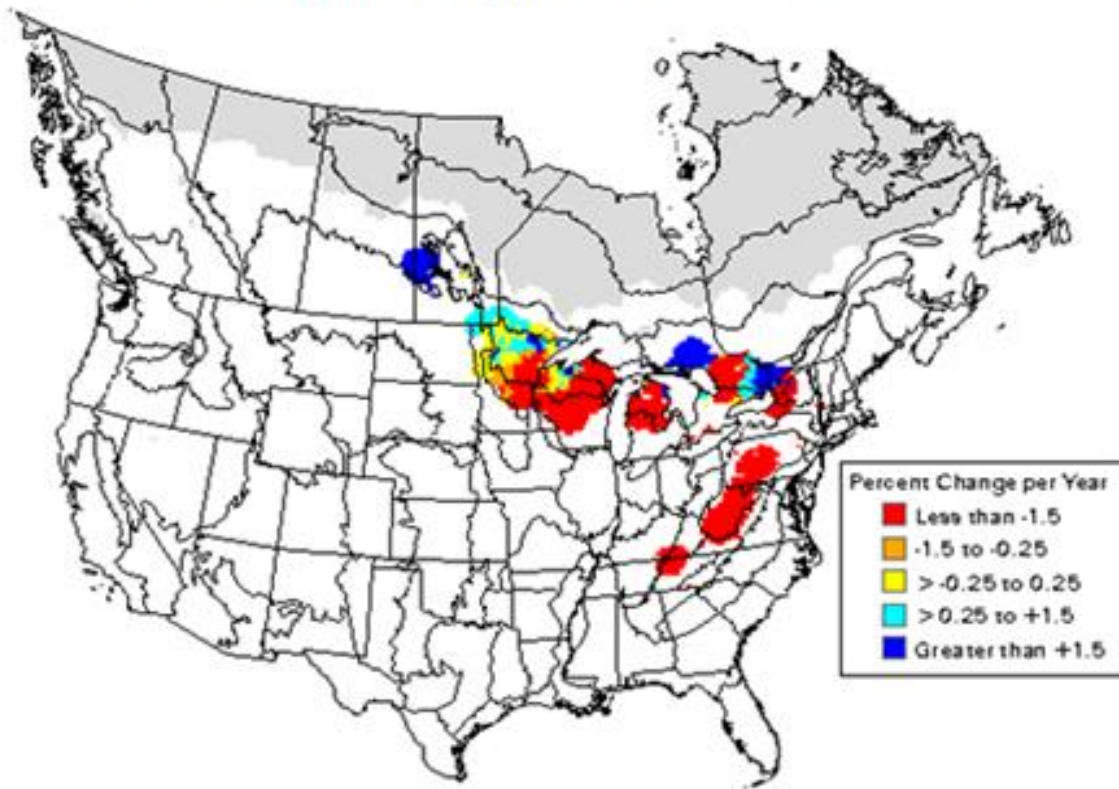


Figure 5. Breeding Bird Survey population trends in GWWA since 1966 (<http://www.mbr-pwrc.usgs.gov/bbs/tr2013/tr06420.htm>).

Habitat

GWWA may utilize different habitat criteria depending on multiple environmental variables, including whether the shrubland is contained within a wetland or is upland (Pistolesi et al., 2015). Requirements may also change based on whether the shrubland has evenly distributed patches of forest within (silviculture), or whether the shrubland contains only early successional species (non-forested) (Roth et al., 2012). Additionally, the preferred ratio of land cover types can change once the habitat is outside of a breeding territory (McNeil, 2015; Roth et al., 2012). Other factors for consideration of GWWA habitat can include plant species composition within

territories, while other management plans may suggest avoiding managing for specific plant communities (Peterjohn, 2006). Because of all these variables, the habitat criteria for GWWA is considered dynamic and it is difficult to identify one set of criteria for selection (Confer, 2014). Taking this information into consideration, however, management plans do make recommendations for land cover ratios preferred by GWWA.

GWWA select shrubland habitat with large amounts of herb and shrub cover and minimal tree cover, located near wetlands, where they build nests on the ground (Confer, 2011; Bullock and Buehler, 2008). GWWA prefer shrubland consisting of regenerating clear-cuts and wet thickets, which are typically within one mile (approximately 1610 meters) of other open area habitats such as wetlands, roads, landings, trails, or edges of old fields (Bakermans et al., 2011). Wetlands especially can be important habitat features for GWWA (Pistolesi et al., 2015; Confer et al., 2010). In the St. Lawrence River Valley, the closest region to this study's AOI where GWWA studies have been conducted, GWWA select swamps with scattered areas of shrubland (Confer, 2011; Rush and Post, 2008). These shrubland areas that contain wet successional woodlands have been shown to have reduced numbers of Blue-winged Warblers nesting in them, reducing the chances of hybridization (Confer, 2014; Thogmartin, 2010; Confer, 2008). Typical breeding territories can range from <0.4 – 6.0 hectares (Table 1) (Roth et al., 2012; Bakermans et al., 2011; Peterjohn, 2006).

Table 1. Regional breeding territory areas for GWWA from literature review.

<u>Source</u>	<u>Region</u>	<u>Breeding Territory Sizes</u>
Roth et al., 2012	NY, PA, Ontario	1.0 ha – 2.0 ha
Bakermans et al., 2011	PA, Maryland	0.4 ha – 4.9 ha
Peterjohn, 2006	Mid Atlantic	0.4 ha – 6.0 ha

Table 2 (Roth et al., 2012) presents recommendations for GWWA habitat land cover ratios in parts of New York and Ontario (outside the AOI). In states nearby New York, like Pennsylvania and Maryland, recommendations for habitat configurations utilize similar habitat ratio values (Bakermans et al., 2015; Bakermans et al., 2011). Further from the AOI (in the Appalachian Range), values are also on par with the Roth’s 2012 report (Golden-winged Warbler Working Group, 2013). This suggests that although GWWA habitat choices are dynamic, it may be possible to utilize similar management recommendations in various parts of the range.

Table 2. Land-cover recommendations for GWWA in different regions of the range.

<u>Region</u>	<u>Shrub/Sapling</u>	<u>Forest Cover</u>	<u>Herbaceous</u>	<u>Bareground</u>
NY, Ontario	30 - 70%	10 - 30%	no data	>0 - 25%
PA, Maryland	30 – 50%	10 – 25%	10 – 25%	>0 – 30%
Appalachian Range	30 – 70%	10 – 30%	no data	>0 – 25%

General Management for Shrubland Birds

Traditionally, early successional forests in the northeast were maintained by wild fires, beavers, indigenous farming practices, and hurricanes on the coast. Trends in fire suppression, disappearance of beavers in the northeast, urban development, and failure to maintain early successional forests has dramatically decreased the amount of habitat for shrubland dependent bird species (DeGraaf & Yamasaki, 2003). Current approaches for managing habitat for shrubland birds include prescribed grazing, prescribed burns, timber harvesting, utility rights-of-way, selective cutting, and clear cutting (Bakermans et al., 2015; Confer, 2011).

Prescribed grazing helps shrubs regenerate, and in cases where invasive plant species like *Phragmites* have overrun shrublands in some areas, the use of goat grazing has been effective in controlling these and other invasive species (Roth et al., 2012). Utility rights-of-way refer to

areas cleared for physical structures like power lines, which often run through forests. Power line clearings can provide a significant amount of early successional habitat in areas disturbed by anthropogenic development. These clearings can provide one hectare of shrubland for every section of 100m wide by 100m long corridor segment with power lines (DeGraaf & Yamasaki, 2003). Timber harvesting and selective cutting of trees should allow for the creation of patch distribution of shrublands mixed in with other land cover types such as mature/old forests, early succession habitats, and young forests (DeGraaf & Yamasaki, 2003; Degraaf, 1992). Shrublands can thrive within these forests by evenly removing canopy from the parent stand to promote the growth of understory shrubs and woody vines. This practice of selective cutting is referred to as an even-age silviculture system, and is considered a highly beneficial for the management of GWWA (Bakermans et al., 2011; Dessecker et al., 2006). By integrating patches of shrublands in these various landscapes, the impact on more mature forests can be reduced, allowing for a more diverse integration of habitats and species (DeGraaf & Yamasaki, 2003).

Patches should utilize a mosaic treatment, where vegetation layers are mixed and composed of shrubs, saplings, grasses, forbs, and residual trees (Bakermans et al., 2015). The mosaic approach is important, because the species dominating a shrubland can impact the amount of upkeep and management required (Tefft, 2006). Areas dominated by mostly regenerating shrub species like blueberry, alder, and dogwood, may last up to 40 years with little management. Shrub species like these have the ability to suppress forest regeneration and tree growth. Shrub areas made up of younger late successional trees, like maple and oak, may only last ten to 15 years before they mature past early-successional habitat (Tefft, 2006). Additionally, managed patches should not be isolated from other shrubland patches, as this will decrease the likelihood of animal occupants (DeGraaf & Yamasaki, 2003).

How often plots are disturbed is also important to shrublands birds, especially for GWWA, and decisions about frequency of disturbance should be based on plant species composition and tree maturity (Bakermans et al., 2015; DeGraaf & Yamasaki, 2003). Table 3 shows the plant species in the northeast utilized by GWWA for food, cover, and nesting materials.

Table 3. Northeastern plant species utilized by GWWA (Roth et al., 2012; Bakermans et al. 2011).

<u>LATIN NAME</u>	<u>COMMON NAME</u>	<u>LAND CLASSIFICATION</u>	<u>FOOD</u>	<u>COVER</u>	<u>NEST</u>
<i>Abies balsamea</i>	balsam fir	Coniferous	Y	Y	N
<i>Acer rubrum</i>	red maple	Deciduous	Y	Y	N
<i>Betula papyrifera</i>	paper birch	Deciduous	Y	Y	N
<i>Comptonia peregrine</i>	sweetfern	Shrub	Y	Y	Y
<i>Elaeagnus umbellata</i>	autumn olive	Shrub	Y	Y	Y
<i>Larix laricina</i>	tamarack	Coniferous	Y	Y	N
<i>Lonicera japonica</i>	honeysuckle	Shrub	Y	Y	Y
<i>Picea glauca</i>	white spruce	Coniferous	Y	Y	N
<i>Pinus banksiana</i>	jack pine	Coniferous	Y	Y	N
<i>Pinus resinosa</i>	red pine	Coniferous	Y	Y	N
<i>Pinus strobus</i>	eastern white pine	Coniferous	Y	Y	N
<i>Populus balsamifera</i>	balsam poplar	Deciduous	Y	Y	N
<i>Populus grandidentata</i>	big-tooth aspen	Deciduous	Y	Y	N
<i>Populus tremuloides</i>	quaking aspen	Deciduous	Y	Y	N
<i>Prunus serotina</i>	black cherry	Deciduous	Y	Y	N
<i>Quercus macrocarpa</i>	bur oak	Deciduous	Y	Y	N
<i>Quercus rubra</i>	northern red oak	Deciduous	Y	Y	N
<i>Rosa multiflora</i>	multiflora rose	Shrub	Y	Y	Y
<i>Rubus fruticosus</i>	blackberry	Shrub	Y	Y	Y
<i>Rubus idaeus</i>	raspberry	Shrub	Y	Y	Y
<i>Vaccinium boreale</i>	blueberry	Shrub	Y	Y	Y

GWWA Conservation and Management

The Golden-winged Warbler Working Group (www.GWWA.org) is an organization devoted to the conservation and creation of GWWA habitat. They were formed in 2003 and consist of hundreds of ornithologists, conservationists, land managers, and federal and state

agencies from the United States, Latin America, and Canada. Their mission supports the conservation of GWWA through education, science, and management practices.

In addition to the Golden-winged Warbler Working Group, there exist GWWA management plans and reports that offer specific recommendations on acreage, composition of plants within shrubland patches, and considerations for habitat outside the patches. These plans were utilized for this study to create criteria for GIS models: “Golden-winged Warbler Habitats in the Appalachian Region” (Golden-winged Warbler Working Group, 2013), “Golden-winged Warbler Status Review and Conservation Plan” (Roth et al., 2012), “Golden-winged Warbler Habitat: Best Management Practices for Forestlands in Maryland and Pennsylvania” (Bakermans et al., 2011), and Peterjohn's technical report titled “Conceptual Ecological Model for Management of Breeding Shrubland Birds in the Mid-Atlantic Region” (Peterjohn, 2006).

Newer management plans include the NYSDEC's 2016 Young Tree Initiative, which aims to convert ten percent of its wildlife management areas (hereafter referred to as WMA) to young forests by implementing timber cuts based on target species needs. Specifically, it will utilize clear cuts to create gaps, allowing sunlight to reach shrubs and other woody plants (NYSDEC, 2016). In addition to an overall protocol, this initiative will create WMA site specific management plans, addressing the site's individual needs to maintain young forest. Monitoring of target species will also be implemented, where response and success are measured. The initiative leaves specific species to be targeted at the discretion of the specific WMA site, with the exception of four species that must be targeted at any area utilizing the initiative. GWWA is one of the four species, along with American Woodcock (*Scolopax minor*), Eastern Whip-poor-will (*Caprimulgus vociferus*), and New England cottontail (*Sylvilagus transitionalis*) (NYSDEC, 2016). Because this new plan specifically requires the creation and

management of GWWA habitat and monitoring, it is encouraging for the overall conservation of GWWA in New York. Other organizations managing land holdings that GWWA utilize within the AOI include private, state, and federal organizations such as: U.S. Fish and Wildlife Services (USFWS), Natural Resources Conservation Service (NRCS), US Geological Survey (USGS), U.S. Department of Agriculture (USDA), The Nature Conservancy (TNC), Finger Lakes Land Trust (FLT), and the Genesee Land Trust (GLT).

Co-managing GWWA with other species

GWWA can be considered an umbrella species because the management of GWWA habitat protects other species of conservation concern that utilize similar habitats (NYSDEC, 2016; Bakermans et al., 2015). Approximately 38 species of shrubland/young forest birds of conservation concern would likely benefit from the protection of GWWA habitat because of similarities in breeding environments (Roth et al., 2012). In New York, the following species (Table 4) would also likely benefit from GWWA habitat conservation (Bakermans et al., 2015; Roth et al., 2012; Bakermans et al., 2011; Dessecker et al., 2006). These species are listed by the NYSDEC as either greatest conservation need or game animals (NYSDEC, 2005).

Table 4. Animal species in New York that utilize GWWA habitat.

<u>Common Name</u>	<u>Latin Name</u>	<u>Taxon</u>	<u>New York Status</u>
American Woodcock	<i>Scolopax minor</i>	Bird	Greatest Conservation Need
Black Bear	<i>Ursus americanus</i>	Mammal	Large Game
Bog Turtle	<i>Glyptemys muhlenbergii</i>	Reptile	Greatest Conservation Need
Eastern Whip-poor-will	<i>Antrostomus vociferus</i>	Bird	Greatest Conservation Need
Fisher	<i>Martes pennanti</i>	Mammal	Small Game
New England Cottontail	<i>Sylvilagus transitionalis</i>	Mammal	Greatest Conservation Need
Ruffed Grouse	<i>Bonasa umbellus</i>	Bird	Greatest Conservation Need
Snowshoe Hare	<i>Lepus americanus</i>	Mammal	Small Game
White-tailed Deer	<i>Odocoileus virginianus</i>	Mammal	Large Game

The inverse is also applicable, and management plans already in place for some of the animals listed in Table 4 could be implemented in the study area to help benefit GWWA. Current existing management protocols like the American Woodcock Conservation Plan and the Ruffed Grouse Conservation Plan could be used by land managers to benefit GWWA (Roth et al., 2012; Kelley et al., 2008; Dessecker et al., 2006). The Ruffed Grouse Conservation Plan objectives are to compare habitat and populations of this species from 1980, when abandon lands likely matured past early-successional stages, to the present conditions (Dessecker et al., 2006). Additionally, this plan identifies habitat availability and management objectives to sustain Ruffed Grouse (*Bonasa umbellus*) populations. The report suggests practices for land management, including utilizing an even-age silviculture system (Dessecker et al., 2006).

The American Woodcock Conservation Plan utilizes similar strategies for recommendations to increase woodcock populations and increase woodcock habitat (Kelley et al., 2008). Overall, the management of American Woodcock (*Scolopax minor*) habitat has been found to be beneficial to GWWA, since both species utilize similar early successional habitat (Bakermans et al., 2015; Dettmers, 2003).

Area of Interest (AOI)

Lower Great Lakes Plain. The Finger Lakes Region is part of the 4.8 million hectare Lower Great Lakes Plain/St. Lawrence Plain Region, characterized by Partner's in Flight as an important bird conservation area for shrubland birds because it currently contains the majority of the shrublands in New York (Milliken et al., 2005; NYSDEC, 2005b; Partners in Flight, 2003). This area also houses the St. Lawrence Valley, which holds the largest populations of GWWA within the state (Confer, 2011). Figure 6 (Atlantic Coast Joint Venture, 2007) shows the Lower

Great Lakes Plain, as defined by the Atlantic Coast Joint Venture (www.ACJV.org). The Atlantic Coast Joint Venture is an organization, comprised of a partnership of seventeen state's wildlife agencies, whose focus is on conserving habitats for migratory birds located within the Atlantic Flyway (Milliken et al., 2005).



Figure 6. Lower Great Lakes Plain area in green (<http://acjv.org/planning/bird-conservation-regions/bcr-13>).

Southeast Lake Ontario Basin

The area of interest (AOI) is also within the Southeast Lake Ontario Basin (Figure 7), which is an area that covers approximately 1.7 million hectares of land (NYSDEC, 2005b). The Southeast Lake Ontario Basin has a smaller defined area than the Lower Great Lakes Plain because it encompasses only areas within New York (including all of the Finger Lakes); while

the Lower Great Lakes Basin covers five states, and a Canadian province: Pennsylvania, New York, Ohio, Michigan, and Ontario, Canada.

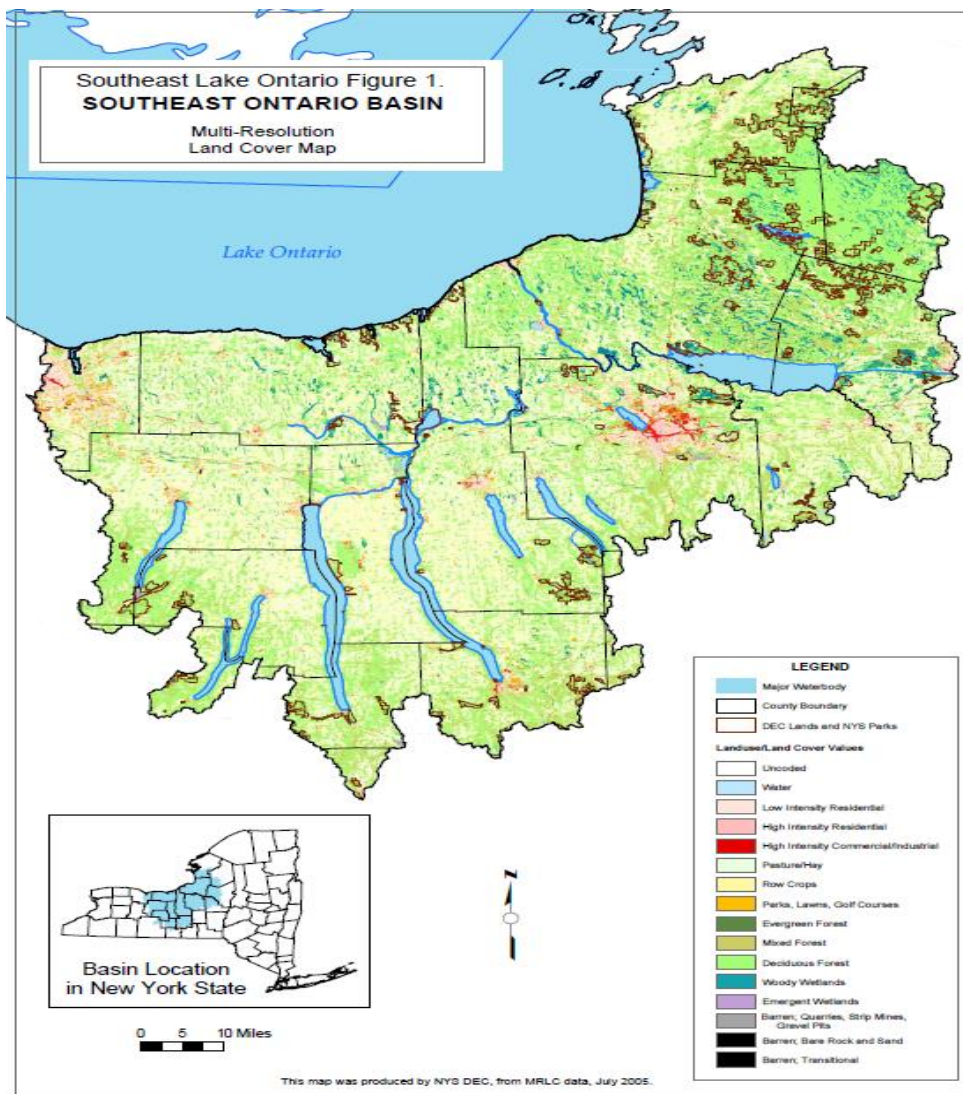


Figure 7. Southeast Ontario Basin (http://www.dec.ny.gov/docs/wildlife_pdf/cwcs2005.pdf).

The NYSDEC has stated that forests within the Southeast Lake Ontario Basin contain at least 38 animal species of greatest conservation need in New York, including GWWA.

Additionally, they have stated this land is considered a critical breeding area for birds that utilize early succession habitat, such as the GWWA (NYSDEC, 2005b). Also contained within the AOI is New York's only national forest, the Finger Lakes National Forest. This forest is

approximately 6,475 hectares, with approximately 1,012 hectares being shrublands that could potentially be utilized by the GWWA (NYSDEC, 2005b).

Geographic Information Systems

Computer mapping programs such as geographic information systems (GIS) are utilized to help create maps and models for conservation plans of many animal and plant species globally (González et al., 2015; Hooftman and Bullock, 2011). By utilizing remote sensing data and aerial photography, current and historic land cover and vegetation data can be assessed to study change of land use over time (Hooftman and Bullock, 2011). These types of data allow users to create mapping models without physically travelling to sites, which is useful when trying to identify potential habitat for a species on hard to access areas such as private lands or remote forests without roads nearby (González et al., 2015; McNeil, 2015).

This type of land cover data is used by ornithologists in the creation of habitat suitability models (HSMs) (Pistolesi et al., 2015; Cardador et al., 2014; Tattoni et al., 2012; Russell et al., 2007). HSMs utilize published data on habitat preferences for a species, to create a map of where you would expect to find the species (Correa-Berger, 2007). By using pre-established habitat criteria for a species, such as proximity to wetlands or distance to edge habitat, you can create buffers around land cover types to identify those sites meeting the habitat preferences (McNeil, 2015; González et al., 2015). As more habitats constraints are added, the number of suitable sites shrinks, until you are eventually left with the highest suitability habitats for a species. This process of eliminating sites based on habitat criteria is referred to as the iterative-reduction process, where the final sites represent the most ideal areas where we would expect to find a target species (Correa-Berger, 2007; Russell et al., 2007).

Once these ideal sites are identified by the model, their accuracy can be verified using empirical sighting data for a species, such as historic bird sighting records, where the sightings are compared with the habitat predicted by the model (Cardador et al., 2014, Thogmartin, 2010). By overlaying empirical data from previous bird sightings, the strength of the model in predicting presence or absence of the target species can be tested (Zohman et al., 2013). The presence of the species within the final seed sites acts as an indicator of the model's effectiveness, suggesting that the model was effective in predicting where a species may be found (Correra-Berger, 2007). These final selected habitat sites would be recommended to land managers as potential areas where a species is likely to occur, where the species should be searched for in the field, and where to focus resources.

Validating mapping models through the use of sighting data is a common technique used by ornithologists (Cardador et al., 2014; Thogmartin, 2010; Russell et al., 2007), where historic sighting data from resources like the Breeding Bird Survey (BBS) and Cornell's eBird Program (eBird) are utilized because of their immense information on population trends and distribution accounts (Kelling et al., 2013; Tattoni, 2012; Wood et al., 2011; Sullivan et al., 2009). This study will utilize sighting data from BBS and eBird to show areas where GWWA have been sighted previously within the AOI and to see if the final seed sites created by the habitat suitability models overlap with them.

Sighting Data

Breeding Bird Survey

The Breeding Bird Survey (BBS) is a program aimed at estimating population trends of bird species that nest in North America (Butcher et al., 1993). It is an ongoing program

administered by the U.S. Fish and Wildlife Service and Canadian Wildlife Service to create a database of information for scientists, allowing them to track population trends and relative abundance using long term data dating back to 1966 (Butcher et al., 1993). BBS routes are 24.5 miles long, and only mark a bird's absence/presence along a route, not their specific location (Sauer et al., 2014). Because of the lack of specific locations of a bird along a route, sighting data can be used in a broad sense (presence/absence) but not to identify longitude/latitude points of where a species has been detected. BBS Routes within the study area date back to 1966, with start and stop points remaining the same over time, making BBS route data useful in looking at long term changes of bird populations (Sauer et al., 2014). Routes are conducted from the end of May until early June, with the goal being to conduct each route annually. Each route is not always visited annually, however, which may be because BBS relies on volunteers to collect data.

Cornell's Lab of Ornithology eBird Program

eBird also tracks distribution and abundance of bird species, although it is not limited to documenting breeding birds like BBS, and includes sightings of all species encountered throughout the year. Cornell's eBird is a citizen science based program, whose contributors are mostly birding enthusiasts (Kelling et al., 2013; Wood et al., 2011; Sullivan et al., 2009). Although eBird's records contain data from users who may not be scientists, their reports are regularly used for scientific research and are considered reliable for the detection of GWWA within the AOI (Confer, 2014; Wood et al., 2011). As of 2016, eBird holds more than one-third of a billion bird observation reports worldwide, including many historical accounts that precede eBird's creation (Kelling et al., 2013; eBird, 2012).

As a means to filter out erroneous data, eBird uses an advanced algorithm that identifies any rare/unusual bird sightings (based on range of the species and date of detection), and asks the submitter to confirm the sighting and provide more data details, i.e. physical description of the bird (Sullivan et al., 2009). Additionally, as of 2013, there are about 450 expert volunteer reviewers who review flagged sightings and follow up with the submitter to confirm the sighting, at which point the sighting is considered vetted (Kelling et al., 2013).

Potential issues with eBird data include reports of sightings for all GWWA in the Western Finger Lakes, not just breeding GWWA, so sightings may be transitional migrating birds headed further north to breed. Resting areas (stop-over sites), like Braddock Bay on the South Shore of Lake Ontario within the AOI, offer repose and food resources for migrating song birds passing through (Bonter et al., 2007). Braddock Bay has numerous records on eBird of GWWA (eBird Basic Dataset, 2014), but these birds may not be nesting here, rather just refueling. One way to account for migrating versus breeding birds is by setting date filters on eBird, where only records that line-up with typical breeding periods of May to mid-July are kept.

Other potential issues with eBird may arise from underreporting in counties with fewer people or in areas where public access is restricted, resulting in a lack of data, and leaving the possibility of spatial bias (Kelling, 2013; Fink, 2010). BBS offers coverage in most of the counties within the AOI, which may help offset spatial bias (Sauer et al., 2014).

Absence of GWWA Habitat Data within AOI

In New York, GWWA have experienced population decreases of up to 53% in the last three decades (Confer, 2010; Confer, 2008). Because of this decline, the New York State Department of Environmental Conservation has called for management plans focusing on

GWWA and their habitat (NYSDEC, 2016; NYSDEC, 2005b). Creating successful management plans for GWWA has proved difficult because of their small population size and a lack of information on population distribution, leaving land managers uncertain where to devote resources (Roth et al., 2012; Thogmartin, 2010). In the states with the highest GWWA populations, like Wisconsin, Minnesota, and Michigan, the majority of the species are found on private lands, making federal or state conservation initiatives even more difficult (Confer, 2011; Thogmartin and Rohweder, 2009). Although the organizations and management plans currently in place play an important role in GWWA conservation, they may not take into account the specific challenges of implementations of management plans within the AOI, which can include the amount of private or inaccessible property, condition/amount of shrublands, and number of land management agencies currently operating.

This study could find no other research looking at GWWA populations or habitat loss in the Western Finger Lakes Region of New York (NYSDEC's Region 8). Studies conducted nearby in Oswego and Ithaca, New York, the state of Pennsylvania, and the Canadian Province of Ontario could provide insight into creating a management plan within the AOI. A model identifying GWWA habitat, as well as other declining species that utilize similar habitat, in an unstudied area, would be useful for land managers looking for locations to focus GWWA conservation efforts. The model's methods could also be used outside of the state, as the habitat criteria could be utilized across the range, as long as useful land cover data is available.

PROJECT GOALS

This study aims to create a habitat suitability model (HSM) in ArcGIS that predicts where GWWA habitat should be found in the Western Finger Lakes Region. The model will utilize current GWWA management plans, expert opinion, and literature review as the basis for the land cover requirements. This study will validate the model results by overlaying empirical sighting data from eBird and BBS, to see if the identified habitat sites have GWWA present. Final seed sites created by the model will be considered highly suitable GWWA breeding habitat, and can be used as a map for land managers and researchers looking for areas to concentrate GWWA conservation efforts in the Western Finger Lakes Region of New York. The model will also identify public/managed land holdings within the AOI that contain the most prime habitat sites, in order to aid in identifying viable locations for GWWA conservation plans, like the NYSDEC's Young Tree Initiative.

METHODS

Area of Interest

This study aims to model suitable habitat and the presence/absence of Golden-winged Warblers (GWWA) in the Western Finger Lakes Region in New York State (NYSDEC's Region 8). The counties that make up this area are: Chemung, Genesee, Livingston, Monroe, Ontario, Orleans, Schuyler, Seneca, Steuben, Wayne and Yates Counties. Figure 8, from the New York State Department of Environmental Conservation, shows these counties. These counties are also located within the Lower Great Lakes Plain Region and Southeast Lake Ontario Basin (Figures 6 and 7).

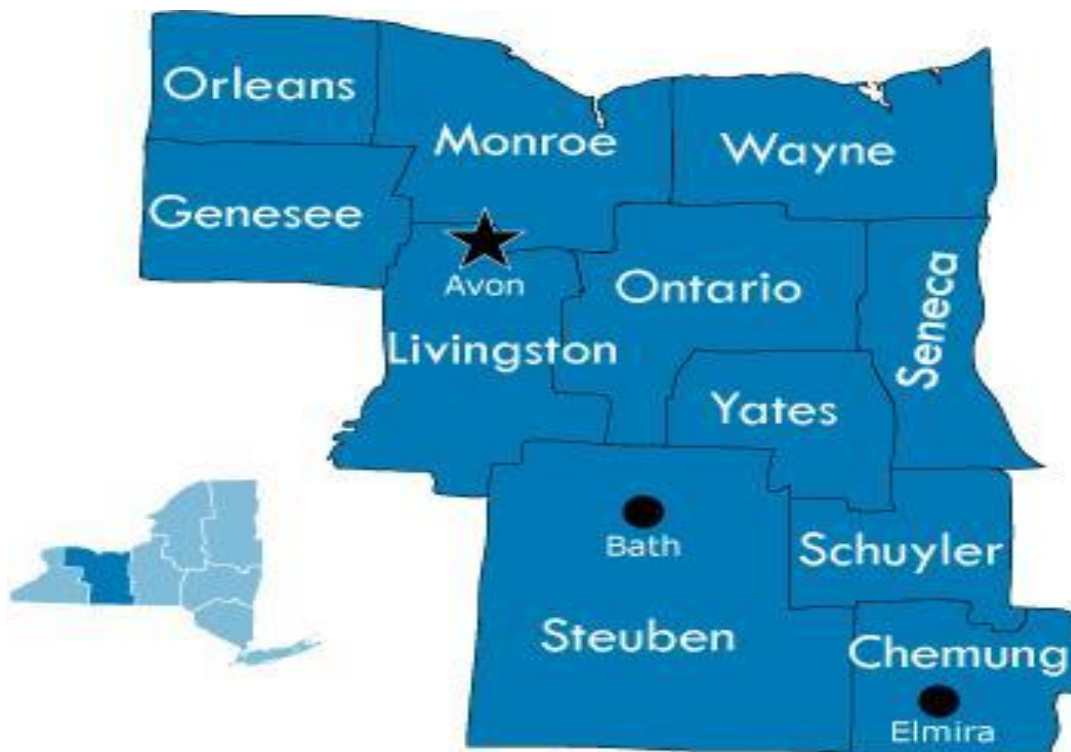


Figure 8. Counties included in the Western Finger Lakes Region of New York. The star represents the DEC headquarters for this region, which is located in the town of Avon, New York. (<http://www.dec.ny.gov/outdoor/7789.html>).

Model Approach

This project utilized the iterative-reduction process (Correa-Berger, 2007) for predicting the most suitable sites for the GWWA. The potential sites (seed sites) were narrowed down by running three iterations (model constraints) based on GWWA habitat recommendations from the literature review (GWWA Working Group, 2013; Roth et al., 2012; Bakermans et al., 2011), until the most suitable sites were identified.

Data Sets

National Land Cover Database

GWWA primarily utilize early successional habitat such as upland and wetland shrublands (Roth et al., 2012; Confer, 2011; Confer, 2010; Bullock and Buehler, 2008; Confer, 2003). Upland shrublands were identified using the 2011 NLCD database and classification, which characterizes shrublands as areas dominated by shrubs (20% or more) or early successional habitat (young trees), with vegetation less than five meters in height (http://www.mrlc.gov/nlcd11_leg.php). The NLCD database has a resolution of 30 meters. Data files were downloaded from the Multi-Resolution Land Characteristics Consortium as raster files, which include both categorical and numerical land cover values (i.e. 52 equals shrubland) (Homer et al., 2015).

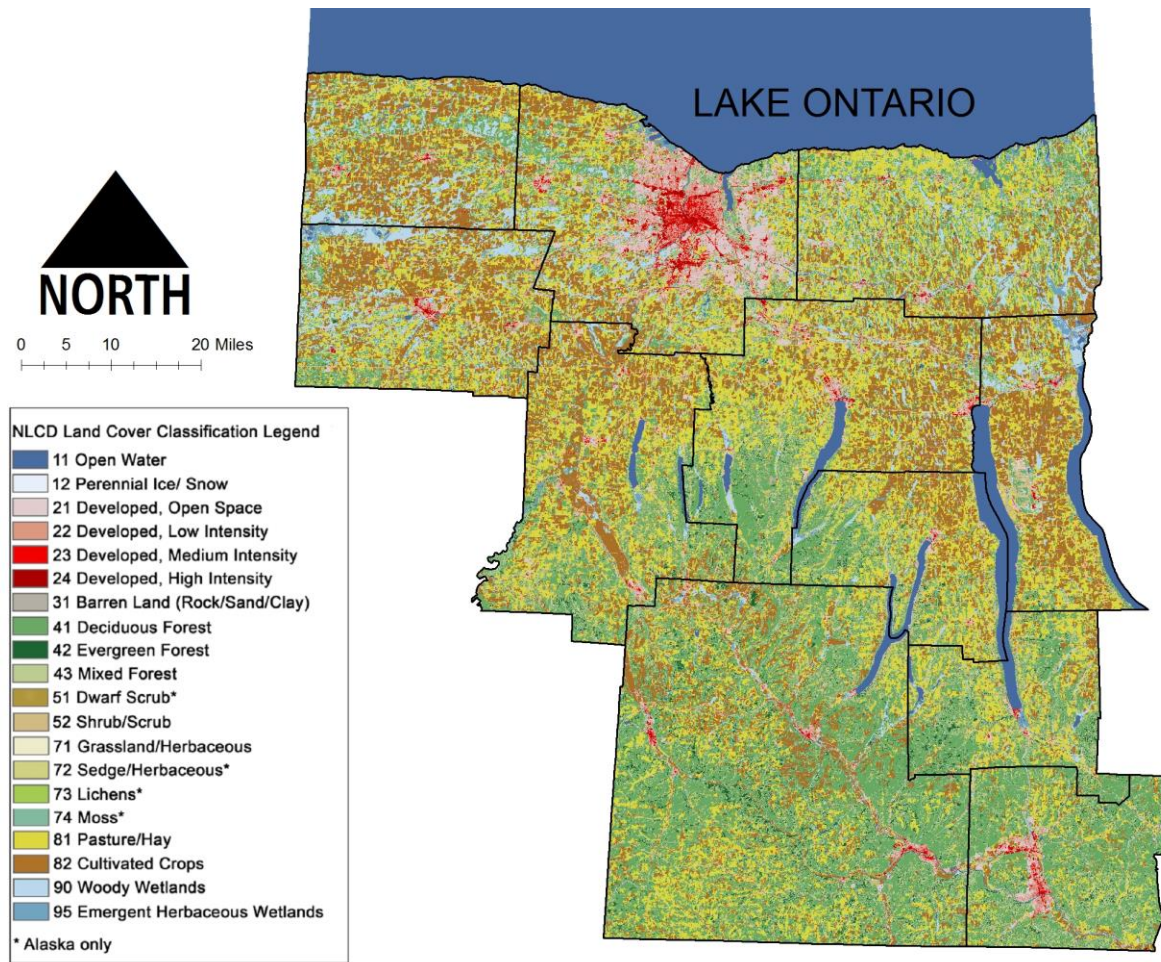


Figure 9. AOI showing 2011 LULC with NLCD legend (www.mrlc.gov/nlcd11_leg.php).

Boundary Data

The county boundary data for areas in the Finger Lakes Region (Chemung, Genesee, Livingston, Monroe, Ontario, Orleans, Schuyler, Seneca, Steuben, Wayne, and Yates) came from the 2010 United States Census county boundaries as vector files (US Census Bureau, 2010; <https://www.census.gov/geo/maps-data/data/tiger-line.html>). The county polygons were used to extract the 2011 NLCD data for the AOI.

Wetlands

This study utilized two types of wetlands data (Pistolessi et al., 2015) for creating the Habitat Suitability Models: NYSDEC state wetland data (NYSDEC, 2008; <http://cugir.mannlib.cornell.edu/datatheme.jsp?id=111>), and the National Wetlands Inventory (NWI) data from the U.S. Fish and Wildlife Services (U. S. Fish and Wildlife Service, 2014; <http://www.fws.gov/wetlands/Data/Mapper.html>). Because wetlands are considered important habitat features for GWWA, NWI and DEC Wetlands data were both ultimately used for iterations and for creating wetlands buffers (Pistolessi, 2013; Confer, 2011; Bullock and Buehler, 2008).

Sighting Data

Shape files for Breeding Bird Survey (BBS) routes were accessed from the USGS websites (Sauer et al., 2014; http://www.mbr-pwrc.usgs.gov/bbs/geographic_information/GIS_shapefiles_2013.html). Data on BBS routes within the AOI, where GWWA were present, were provided directly from BBS Staff Scientists (Ziolkowski, 2014). Data from eBird was received as a Microsoft Excel file, with Latitude/Longitude points for sightings expressed as Decimal Degrees (eBird, 2014).

Public and Managed Lands

The shape files with parcel data for public lands and management organization properties within the AOI were accessed and intersected with prime habitat sites, to see which parcels contained the most GWWA habitat. Data sets utilized account for a majority of the public, private, state, and national agencies managing land within the AOI. Public and government data

sets used include: Natural Resources Conservation Service (NRCS Conservation Easements, 2015; <https://gdg.sc.egov.usda.gov/GDGOrder.aspx>), New York Department of Environmental Conservation (Bureau of State Land Management, 2008; <http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1114>), Protected Areas Database of the United States Geological Survey (USGS, 2012; <http://gapanalysis.usgs.gov/padus/data/download>), and Real Property Tax Office (NYS Department of Taxation and Finance, 2010; <https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1248>).

Private organization data sets analyzed include: Finger Lakes Land Trust (Edelstein, 2015), Genesee Land Trust (Johnson, 2013), and The Nature Conservancy (The Nature Conservancy, 2014).

Elevation

Elevation was found to be a limiting factor for GWWA and Blue-winged Warbler (BWWA) hybridization (Bakermans, 2011; Peterjohn, 2006), but not necessarily a factor for GWWA habitat selection (Confer, 2014). Because of the negative impact hybridization has on GWWA populations, elevation was broadly analyzed in this study, but not used in the iteration process (Patton, 2010; Bullock, 2007; Buehler et al., 2007). Elevation data for the counties in the Western Finger Lakes Region of New York were accessed from Geospatial Data Gateway as raster files with a 30 meter resolution in a GeoTIFF format (US Geological Survey and EROS Data Center, 1983; www.gdg.sc.egov.usda.gov, 10/2015).

Miscellaneous

Statistics from the 2010 New York Census (and annual updates) were used in the analysis for comparing human population of each county to total number of submitted eBird checklists per county (U.S. Census Bureau, 2010; <http://quickfacts.census.gov/qfd/states/36000.html>). The total number of eBird checklists per county in New York was accessed from the eBird raw data database (eBird Raw Data, 2014; <http://ebird.org/ebird/subnational1/US-NY/regions?yr=all&m>). ESRI World Imagery Maps were used for digitization of eBird Reports without reported distances (ESRI, 2011).

Model Steps

Iteration 1

Since shrublands are the preferred primary habitat and nest locations for GWWA, the first iteration was based on sites meeting the minimum habitat requirement of containing upland shrublands, as per the 2011 NLCD classification, which will represent the initial seed sites. Two sets of buffers were set around the initial shrubland seed sites to define breeding territories. The buffer values used were 0.4 ha (36m) and 1.0 ha (56m), which were the minimum values derived from three different management plans for GWWA (Table 5). Buffer distances were calculated using the formula for the radius of a circle. The breeding territory values from the GWWA management plans were not based on research conducted in the Western Finger Lakes Region of New York, so specific values were not available for AOI, however these studies were conducted nearby in Pennsylvania, Ontario, Mid Atlantic, and other parts of New York.

Table 5. Minimum GWWA breeding territory sizes.

<u>Source</u>	<u>Region</u>	<u>Minimum Territory Sizes</u>
Roth et al., 2012	NY, PA, Ontario	1.0 ha
Bakermans et al., 2011	PA, Maryland	0.4 ha
Peterjohn, 2006	Mid Atlantic	0.4 ha

Iteration 2

Iteration 2 utilized the National Wetlands Inventory and NYSDEC wetland data (Pistolessi, 2013), where seed sites were kept if their boundaries touched or were within 1-mile (1610 m) of wetlands (Bakermans et al., 2011). These datasets include wetland shrubs, an important habitat type for GWWA, where hybridization with BWWA is less likely.

Iteration 3

Iteration 3 was based on land cover ratios within the remaining sites (Table 6), keeping sites that correlated with the recommended minimum weighted distribution values for GWWA habitat (Correa-Berger, 2007). Iteration 2 seed sites were intersected with the 2011 LULC layer to extract land cover parameters (Pistolessi et al., 2015), to determine if the seed sites met or exceeded the minimum and maximum habitat distribution values from the management plans (McNeil, 2015). NLCD codes that most closely represent the land cover types in these reports were chosen (Table 7).

Table 6. Minimum GWWA habitat distribution values.

<u>Source</u>	<u>Region</u>	<u>Minimum Shrub</u>	<u>Minimum Forest Cover</u>	<u>Minimum Herbaceous</u>	<u>Minimum Bareground</u>
GWWA Working Group, 2013	Appalachian	30%	10%	N/A	> 0%
Roth et al., 2012	NY, PA, Ontario	30%	10%	N/A	> 0%
Bakermans et al., 2011	PA, Maryland	30%	10%	10%	> 0%

Table 7. Land Cover Codes (NLCD) used for Iteration 3.

<u>Landcover Type</u>	<u>NLCD Code</u>
Shrub/Sapling	52
Forest	41, 42, 43
Herbaceous / Pasture	71, 81
Bareground	31

Data for the intersected LULC sites were exported to Microsoft Excel, where pivot tables were used to analyze LULC ratios based on seed sites IDs. Sites were ranked from 0 to 4 based on whether they met all four minimum LULC recommendation percentages from Table 6 (shrub cover, forest cover, herbaceous cover, and bare-ground). The boolean method was used to denote where sites meeting a given LULC requirement, i.e. at least 30% of the sites were shrubland, by assigning a value of 1 for that habitat category, otherwise that category received a score of 0. Seed sites with values of 4, where all four land cover requirements were met, represent the final sites with the most suitable GWWA habitat. Filtering the sites that did not meet the LULC distribution ratios represents the third iteration.

Model Verification and Bird Sighting Data

Once all the iterations were run, only seed sites that met the habitat criteria from the literature review and expert opinion were left. These remaining seed sites represent the highest value habitat where one would expect to find the target species (Correa-Berger, 2007). Data from the Breeding Bird Survey and Cornell's eBird System were utilized to show presence or absence of a species when overlaid on final seed sites.

Breeding Bird Survey and Cornell Lab of Ornithology's eBird Program

Shape files for BBS routes both with and without GWWA and within the AOI were intersected with prime habitat sites to see whether habitat was detected in BBS routes that reported GWWA. Sighting data for GWWA from eBird contain reported distances and locations the observer utilized. These reports were intersected with prime habitat sites to see whether habitat was detected within the report areas. To reduce the chances of using reports where GWWA may have been misidentified by the observer, the following filters were applied to all raw data sightings from eBird's websites:

- 1) *Include only vetted or peer reviewed data.* This filter was added to eliminate any sightings of GWWA that were not confirmed by the eBird administrators or the systems flagging algorithm. GWWA could be mistaken for other species by amateur citizen scientists; this filtering system helps reduce chances of mistaken identity (Kelling et al., 2013; Wood et al., 2011; Sullivan et al., 2009).
- 2) *Date filters.* Parameters were set to only include sightings from months where breeding is expected, May through mid-July for GWWA (Bakermans et al., 2011; Confer, 2011). Sightings outside this data range could represent migrating birds that are utilizing habitats for stopover refueling, and this type of habitat may not meet the criteria of the HSM, thus skewing the results.
- 3) *AOI Filters.* Filters were applied so that only the Finger Lakes Counties were included in the results. These counties are: Chemung, Genesee, Livingston, Monroe, Ontario, Orleans, Schuyler, Seneca, Steuben, Wayne and Yates Counties.
- 4) *Distance and Location Filters.* Only reports that included effort distance or location description (i.e. state park name, national forest name) were used for analysis.

RESULTS

Iteration-Reduction Process

Iteration 1

After the first part of iteration 1 was completed, 74,946 upland shrubland seed sites were identified in the AOI, which means approximately 11% of the total land cover of the AOI is upland shrubland. Several areas appear to show a high density of GWWA shrubland habitat, which are concentrated in the central part of the AOI; specifically in Livingston, Ontario, Steuben, Yates, Seneca, and Schuyler Counties (Figure 10).

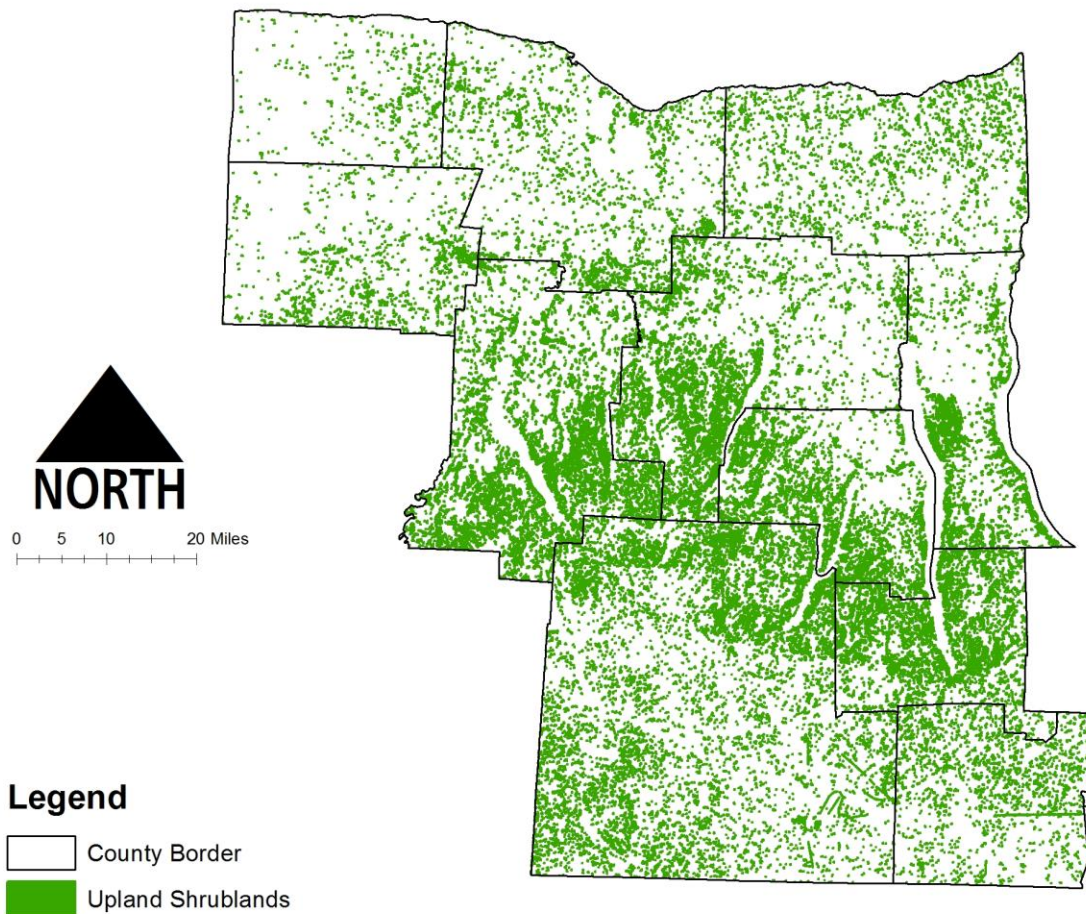


Figure 10. 2011 NLCD shrublands within the AOI.

When iteration 1 was completed, 0.4 ha and 1.0 ha breeding territory buffers (36m and 56m) were placed around all shrublands. These buffers caused sites that were previously separated to touch, creating new contiguous areas. 74,946 shrubland sites fell to 19,908 sites with buffer values 0.4 ha and 15,850 sites with buffer values of 1.0 ha.

Iteration 2

For the second iteration, any sites more than one square mile (1610 m) from NWI and DEC wetlands were discarded, because GWWA utilize habitats within one mile of wetlands. Because of the abundance of wetlands in the AOI and the search distance, iteration 2 resulted in no sites being excluded from iteration 1 results, yielding 19,908 seed sites with buffer values of 0.4 ha and 15,850 seed sites with buffer values of 1.0 ha.

Iteration 3

Iteration 3 ranked the remaining seed sites based on how closely they met the GWWA preferred LULC ratios derived from the literature review (Table 6). The LULC layer (NLCD 2011) and iteration 2 seed sites were intersected in order to analyze the land cover breakdown of the breeding territory sites, creating habitat areas like the image in Figure 11 below. Seed sites IDs were used to identify unique habitat areas for statistical analyses.

Ten sites had scores of 4. The number of highest suitability habitats (scores of 4) was considered low relative to the total number of potential sites, so the land cover parameters were re-evaluated to determine the limiting factor(s).

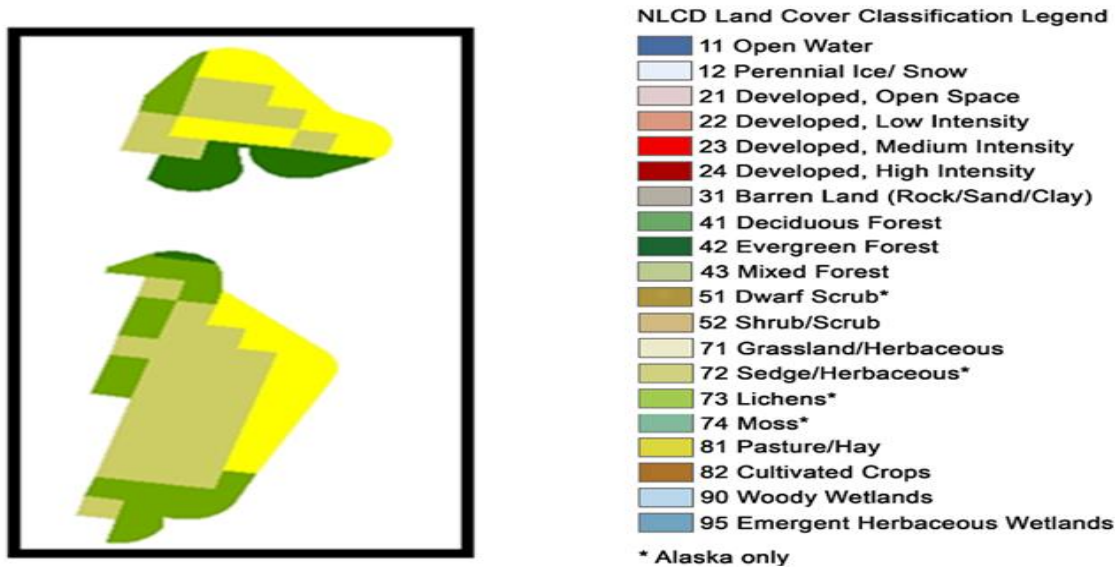


Figure 11. Example of a LULC breakdown within seed sites.

Pivot table analyses of the databases indicate that of the 19,908 seed sites with buffer values of 0.4 ha, 40 had scores of 4, where a score of 4 met all the land cover percentage requirements. Of the 15,850 seed sites with buffer values of 1.0 ha, 10 sites had scores of 4. Based on the LULC categories and cumulative scores, bare ground was found to be scarce in the AOI. Because agriculture fields can be bare ground during the breeding season, the bare ground category was expanded to include agricultural fields/cultivated crops (LULC code 82) and the third iteration was re-run. Including agriculture as an open ground variable increased the number of polygons with the highest total habitat score from 40 to 1696 for seed sites with buffer values of 0.4 ha, and from 10 to 579 for seed sites with buffer values of 1.0 ha (Figure 12). In this revised analysis, the seed sites in orange form a concentration gradient within specific areas of Livingston, Ontario, Steuben, Yates, Seneca, and Schuyler Counties, especially for the seed sites with 1.0 ha buffers. Based on the model predictions, these sites in the central counties of the AOI represent the highest concentration of prime GWWA breeding territory habitat within the

study area. Seed sites with buffer values of 0.4 ha or 1.0 ha, and habitat scores of of 4, will hereafter be referred to as a “Prime Habitat I Site” (utilized a 0.4 ha buffer) or a “Prime Habitat II Site” (utilized a 1.0 ha buffer).

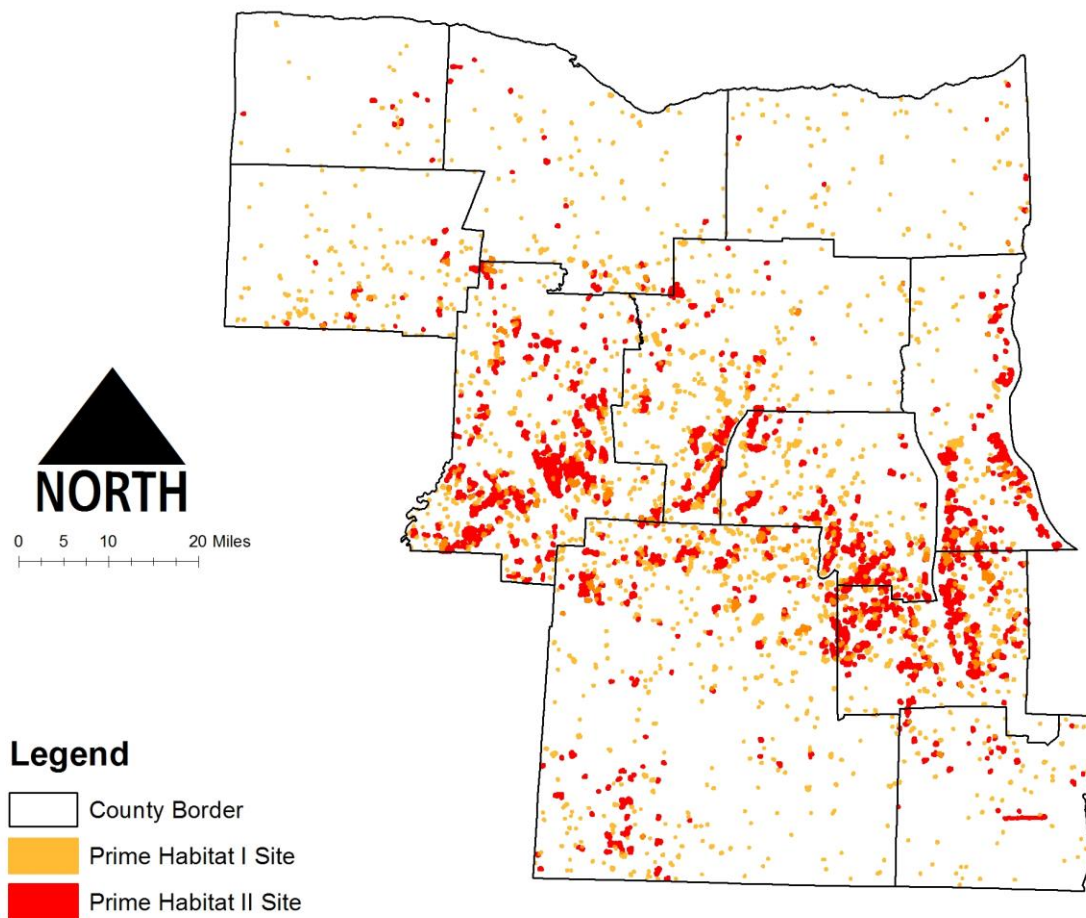


Figure 12. Prime Habitat I and II Sites (0.4 ha and 0.6 ha buffers and habitat scores of 4).

Prime Habitat I and II Sites concentrate in Livingston, Ontario, Schuyler, Seneca, Steuben, and Yates Counties. Within these counties, there is a noticeable concentration gradient, representing where the largest amount of GWWA habitat exists in the AOI. This area will hereafter be referred to as the “Central Band” (Figure 13).

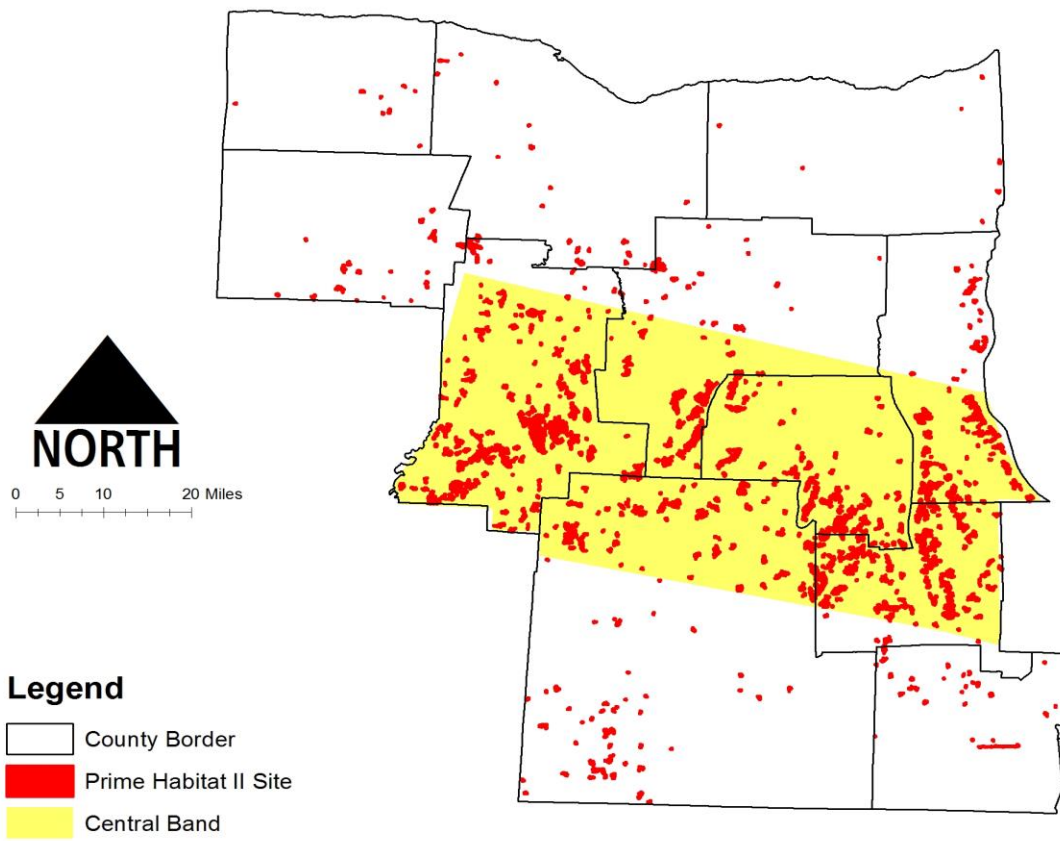


Figure 13. Concentration of prime habitat sites within the Central Band.

Size of Prime Habitat Sites

For iteration 1, buffers of 0.4 ha and 1.0 ha were placed around shrublands that varied in size from less than one hectare to hundreds of hectares. After the land cover analysis was completed in iteration 3, Prime Habitat I Sites (0.4 ha buffer) ranged in size between 1.7 ha to 199 ha in size, with the average size of a site being 7.5 ha (Table 8). Prime Habitat II Sites (1.0 ha) deviated in size between 5.1 ha to 1167.5 ha in size, with the average size of a site being 59.8 ha.

Table 8. Breakdown of Prime Habitat I and II Site values.

<u>Prime Habitat Site</u>	<u># of Sites</u>	<u>Minimum</u> <u>Site Size (ha)</u>	<u>Maximum</u> <u>Site Size (ha)</u>	<u>Mean</u> <u>Site Size (ha)</u>	<u>Total Area (ha)</u>
Type I (0.4 ha Buffer)	1696	1.7	199	7.5	12720.9
Type II (1.0 ha Buffer)	579	5.1	1167.5	59.8	34597.9

Table 9 shows the frequency for sizes of prime habitat site ranges. Of the 1696 Prime Habitat I Sites (utilized 0.4 ha buffer), the majority of sites ranged from 2.0 to 3.9 hectares (highlighted in red), totalling approximately half of the overall sites. Of the 579 Prime Habitat II Sites (utilized 1.0 ha buffer), the majority of sites were 13.0 to 13.9 hectares (highlighted in blue).

Table 9. Frequency and ranges for Prime Habitat I and II Sites. Majority of Prime Habitat I Sites highlighted in red. Majority of Prime Habitat II Sites highlighted in blue.

<u>Site Size</u> <u>Range (ha)</u>	<u>Frequency of</u> <u>Prime Habitat I Sites</u>	<u>Frequency of</u> <u>Prime Habitat II Sites</u>
0.0 - 0.9	0	0
1.0 - 1.9	35	0
2.0 - 2.9	513	0
3.0 - 3.9	314	0
4.0 - 4.9	187	0
5.0 - 5.9	124	4
6.0 - 6.9	77	8
7.0 - 7.9	60	10
8.0 - 8.9	53	9
9.0 - 9.9	40	6
10.0 - 10.9	38	17
11.0 - 11.9	23	15
12.0 - 12.9	14	14
13.0 - 13.9	22	22
14.0 - 14.9	24	16
15.0 - 15.9	6	9
16.0 - 16.9	14	6
17.0 - 17.9	1	11
18.0 - 18.9	11	9
19.0 - 19.9	12	10
20.0 - 29.9	55	106
30.0 - 39.9	24	67
40.0 - 49.9	9	46
50.0 - 99.9	19	107
100.0 - 199.9	7	57
200.0 - 1000	0	29
> 1000	0	1

Breeding Bird Survey Routes

BBS routes were analyzed to detect if prime habitat sites were found on BBS routes with GWWA. Out of the nineteen routes in the AOI, about one-third reported at least one or more GWWA present within the past five years, which are highlighted red in Table 10 (Sauer et al.,

2014; Ziolkowski, 2014). Figure 15 shows BBS routes in green that detected GWWA within the past five years.

Table 10. BBS route data. Routes that have detected GWWA within the past five years which are highlighted in red.

<u>Number</u>	<u>Route Name</u>	<u>GWWA Present</u>	<u>Prime Habitat I</u>	<u>Prime Habitat II</u>	<u>County</u>	<u>Central Band</u>
61049	Branchport	Y	Y	Y	Steuben, Yates	Y
61051	Mendon	Y	Y	Y	Livingston, Monroe, Ontario	Y
61052	Mt Morris	Y	Y	Y	Livingston	Y
61043	Trumansburg	Y	N	Y	Seneca	Y
61054	West Seneca	Y	N	N	Genesee	N
61154	Harris Hill	Y	N	N	Genesee	N
61045	Phillips Cr	N	Y	Y	Livingston	Y
61046	Swain	N	Y	Y	Livingston	Y
61050	Canadice L	N	Y	Y	Ontario	Y
61055	Gainesville	N	Y	Y	Genesee	N
61066	Byron	N	Y	Y	Genesee, Orleans	N
61067	Chruchville	N	Y	Y	Genesee, Monroe	N
61110	Naples	N	Y	Y	Ontario	Y
61146	Swain 2	N	Y	Y	Livingston	Y
61047	Orleans	N	Y	N	Ontario, Yates	Y
61068	Penfield	N	Y	N	Monroe, Wayne	N
61040	Romulus	N	N	N	Seneca	Y
61042	Macdougall	N	N	N	Ontario, Seneca	N
61048	Rushville	N	N	N	Ontario, Yates	Y

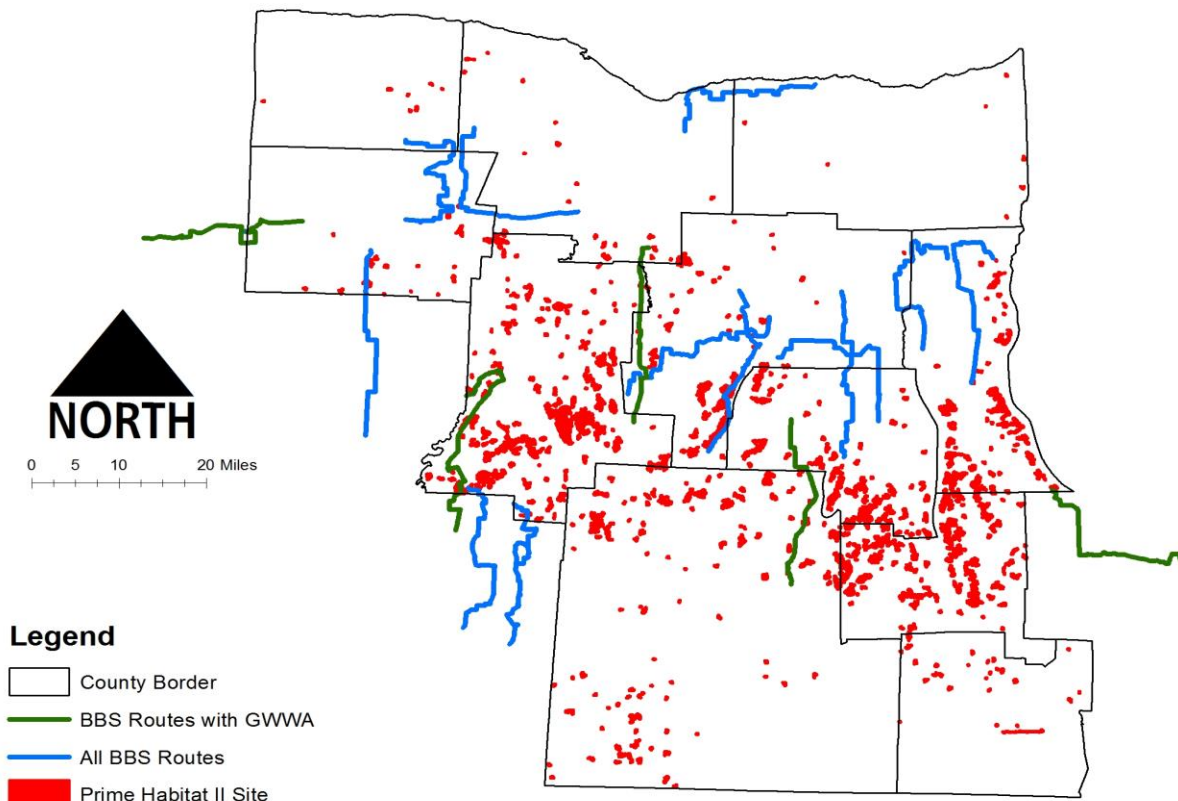


Figure 15. Breeding Bird Survey routes with and without GWWA.

BBS routes that contained prime habitat sites were also identified, where the routes that have detected GWWA in the past five years and contained a prime habitat site are shown in green in Figures 16a and 16b. Those routes that detected GWWA but did not contain Prime Habitat I or II sites are shown in blue. Four out of six of the routes that have detected GWWA in the last five years contained a prime habitat site(s). The routes shown in purple are BBS routes that contained prime habitat site(s), but did not report GWWA, suggesting that these routes emphasize GWWA detection in future data collections.

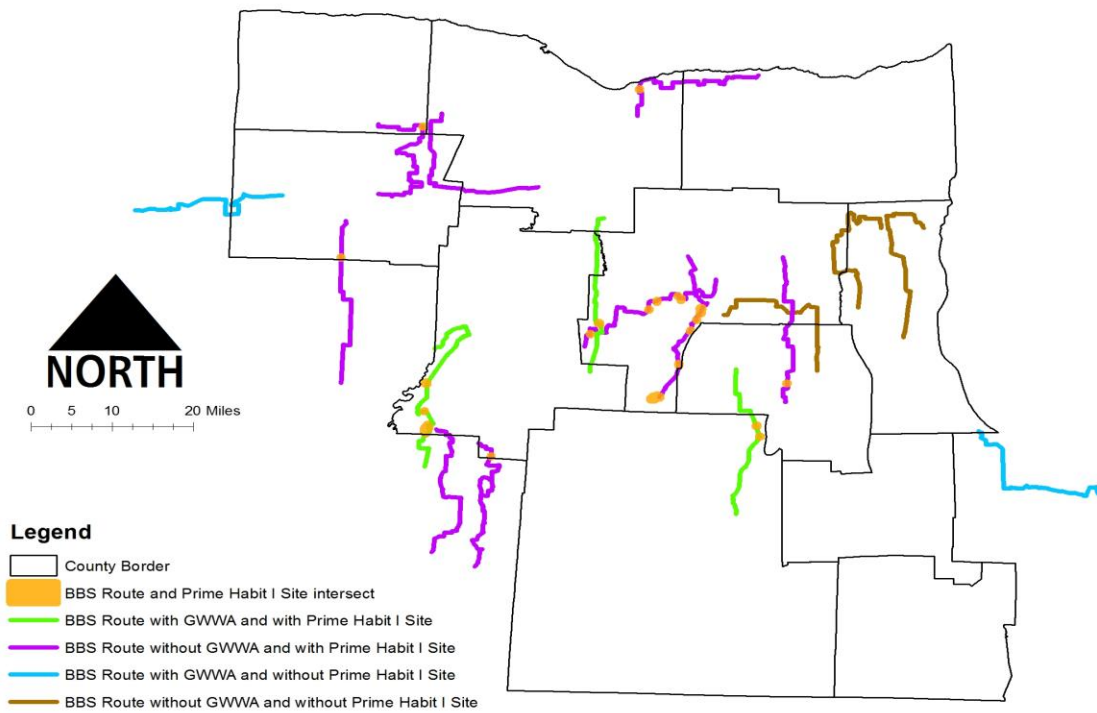


Figure 16a. BBS routes intersected with Prime Habitat I Sites.

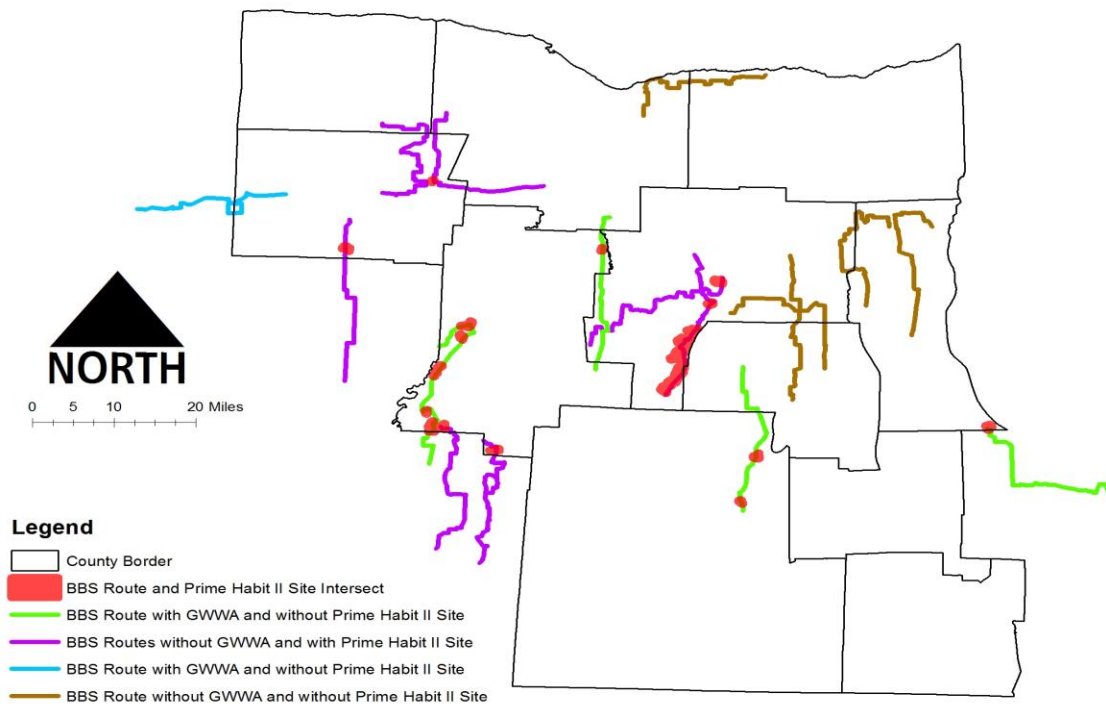


Figure 16b. BBS routes intersected with Prime Habitat II Sites.

Eight out of 13 routes that did not detect GWWA had both Prime Habitat I and II Sites within the same route (Table 10 above). Ten out of the 13 routes that did not detect GWWA contained either Prime Habitat I Sites or Prime Habitat II Sites, but not necessarily both in the same route (Table 10). Overall, Ontario County had the largest area of prime sites that intersected with BBS routes, totalling 1,624 hectares of Prime Habitat I and II Sites (highlighted red in Table 11). It should be noted that within the AOI, Ontario conducted the most BBS routes (six), which may have contributed to a larger total area value. Yates had only three routes but totalled more area (1,099 ha) than counties with five BBS routes, like Livingston and Genesee. Steuben County had only one route (highlighted blue), but had a larger total area of prime habitat sites within a BBS route than counties like Genesee, which had five routes. Chemung and Schuyler Counties currently have no BBS routes being conducted within them. A more detailed analysis of all the BBS results is can be found in the discussion section.

Table 11. County breakdown of BBS routes. Routes highlighted in red contained the most prime habitat sites. Route highlighted in blue had few BBS routes but contained a large amount of prime habitat sites.

<u>County</u>	<u># of BBS Routes</u>	<u>GWWA</u>	<u>Area (ha) of Prime I Sites on BBS Routes</u>	<u>Area (ha) of Prime II Sites on BBS Routes</u>	<u>Total Area</u>
Ontario	6	Y	182	1443	1625
Yates	3	Y	22	1077	1099
Livingston	5	Y	95	593	688
Genesee	5	Y	3	154	157
Steuben	1	Y	8	1	9
Monroe	3	Y	7	0	7
Orleans	1	N	3	0	3
Seneca	3	Y	0	1	1
Wayne	1	N	0	0	0
Chemung	0	N/A	N/A	N/A	N/A
Schuyler	0	N/A	N/A	N/A	N/A

Cornell Lab of Ornithology's eBird Sightings

Observer sightings from the eBird Program were used to see if GWWA were present in prime habitat sites. After filtering out sightings that were not vetted by eBird moderators, not during breeding months, and sightings without specific distances or locations reported, 45 eBird reports remained, shown as point data in Figure 16. The three most northern counties in the AOI, which all border Lake Ontario, had the highest concentration of GWWA (highlighted in red in Table 12). Monroe County had nineteen, Wayne County had eleven, and Orleans County had nine sightings. The number of GWWA sightings for all counties, shown in Table 12, totaled more than 45. This is because some eBird sightings occurred near county boundaries, and if the reported distance for the observation was large, it caused the buffer distance to reach past county boundaries into another, where the sighting was also counted.

Table 12. Number of GWWA per county from eBird data. Counties that reported the most GWWA are highlighted in red.

<u>County</u>	<u>Reported # of GWWA</u>	<u>Central Band</u>
Chemung	0	N
Genesee	6	N
Livingston	2	Y
Monroe	19	N
Ontario	3	Y
Orleans	9	N
Schuyler	1	Y
Seneca	3	Y
Steuben	0	Y
Wayne	11	N
Yates	1	Y

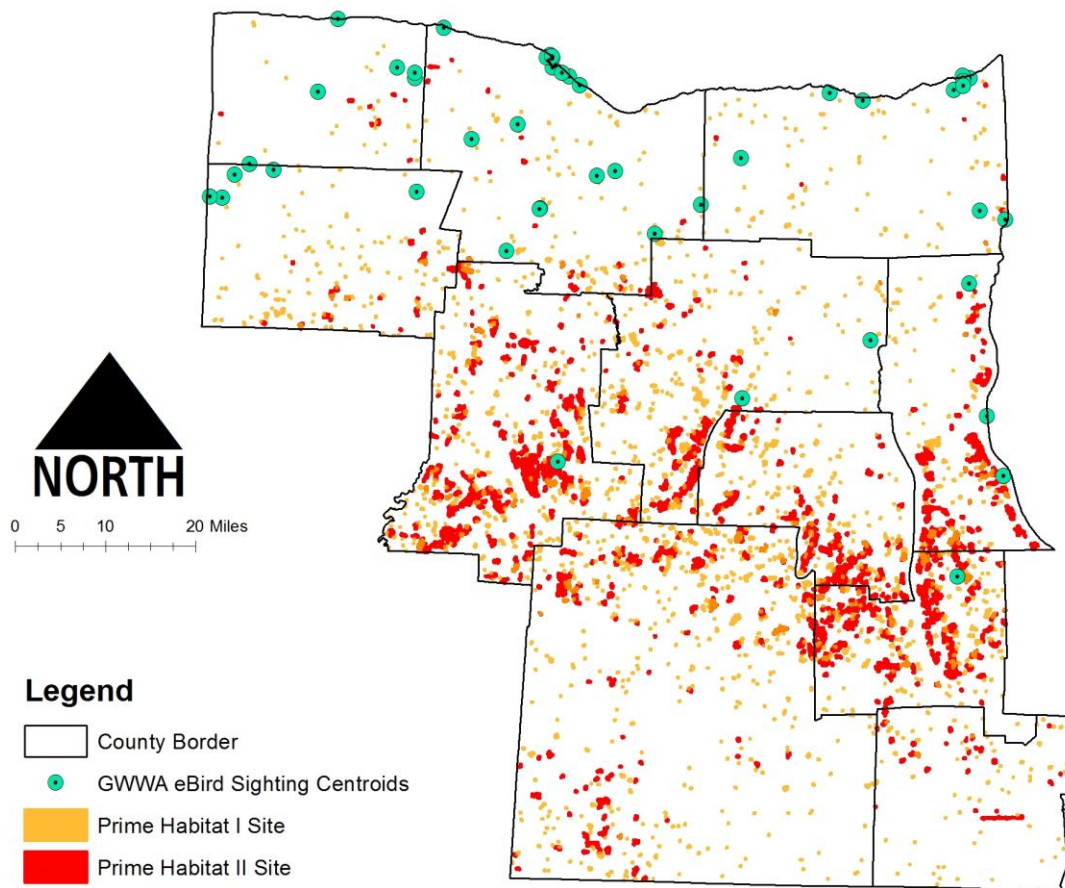


Figure 16. GWWA eBird sightings shown as centroids.

Reported Distances vs. Specific Locations

Out of the 45 eBird GWWA sightings, 32 had associated distances reported in the observer notes, where reported distances ranged from zero meters (stationary) to 1900 meters. For stationary counts, distances were assigned values of 50 square meters, since observers were not standing directly next to GWWA, but rather in close proximity. Most reported distance areas were relatively small with the exception of a report in the southeastern area of the AOI, in Schuyler County. The reported distance here was approximately twelve miles, and the sighting was in the Finger Lakes National Forest. Ultimately, this report was kept because the area

within the Finger Lakes National Forest contained a high number of prime habitat sites, and represented the only national forest in the AOI.

Fourteen of the 45 sightings had no associated distances reported. These sightings had location names associated with them in the reports, i.e. specific parks or preserves like Cobb's Hill Park in Monroe County or Bergen Swamp in Genesee County. Instead of using buffers for these reports, the park boundaries were digitized from NYSDEC Maps and the ESRI World Imagery Map (Figure 17), and used as containment polygons in the analysis.

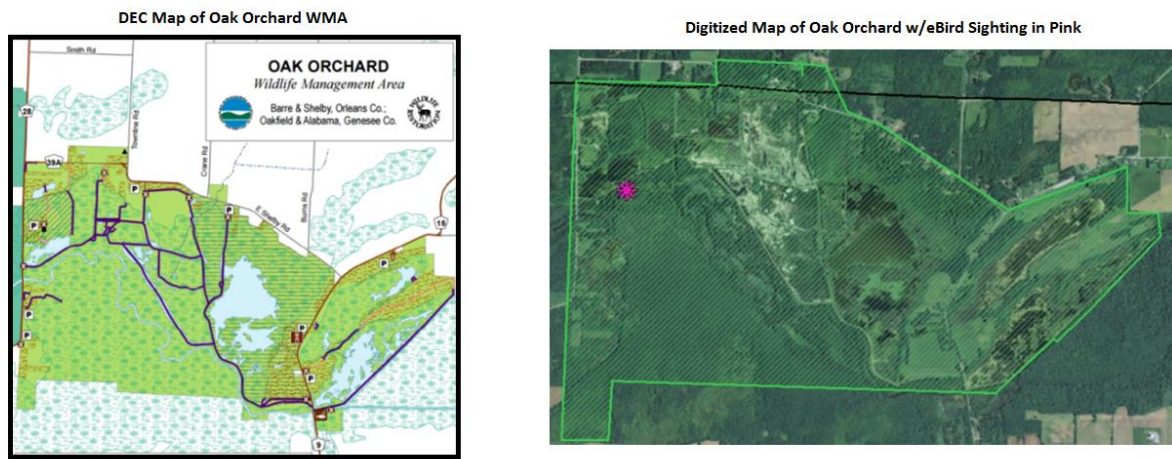


Figure 17. *Left:* DEC Map of Oak Orchard (<http://www.dec.ny.gov/outdoor/24442.html>). *Right:* GIS Digitized Map of Oak Orchard in Genesee County (ESRI, 2011).

Several reports with broad or undefined locations were narrowed to more precise locations after the observer was contacted. For example, an eBird report containing a point in Braddock Bay Park in Monroe County had no distance written, but after the reporter was contacted via email, they explained that the bird in question was seen along the wood edge to the east of the hawkwatch platform in the park.

eBird Sightings Merged

After all area sites were completed they were exported into a new shape file and merged with the eBird Sightings with reported distances (Figure 18).

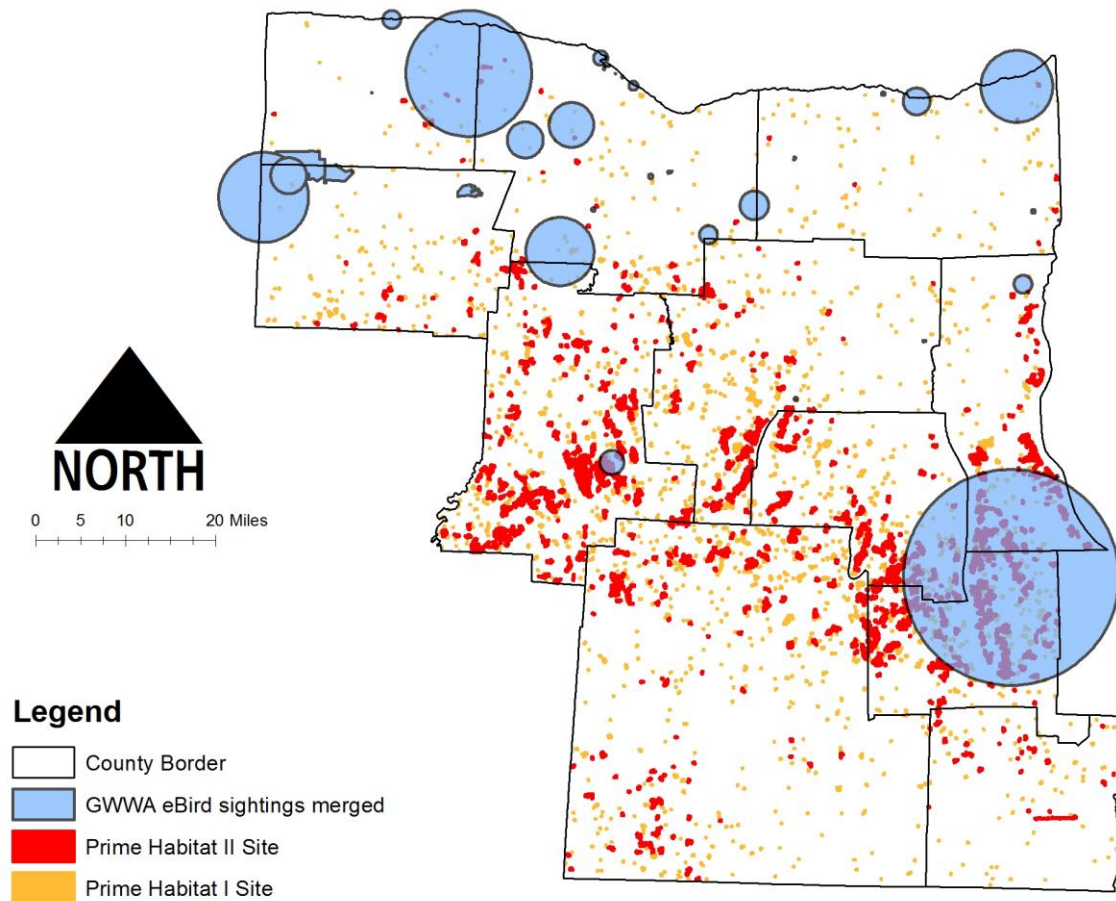


Figure 18. eBird digitized area sites and eBird buffers merged.

Seed sites with prime habitat scores of 4, which are considered the most suitable for GWWA, were intersected with eBird sightings. Fourteen out of the 45 eBird sighting polygons intersected with a Prime Habitat I Site (0.4 ha buffer) (Figure 19a), and eight out of 45 sightings intersected with a Prime Habitat II Site (1.0 ha buffer) (Figure 19b). A majority of intersects occurred in the northern counties, although the eBird reports that contained the most prime

habitat were all located within the Central Band in Livingston, Ontario, Seneca, and Schuyler County. A full analysis of these findings is provided in the discussion section, where the eBird reports with the highest amount of prime habitat sites are further analyzed.

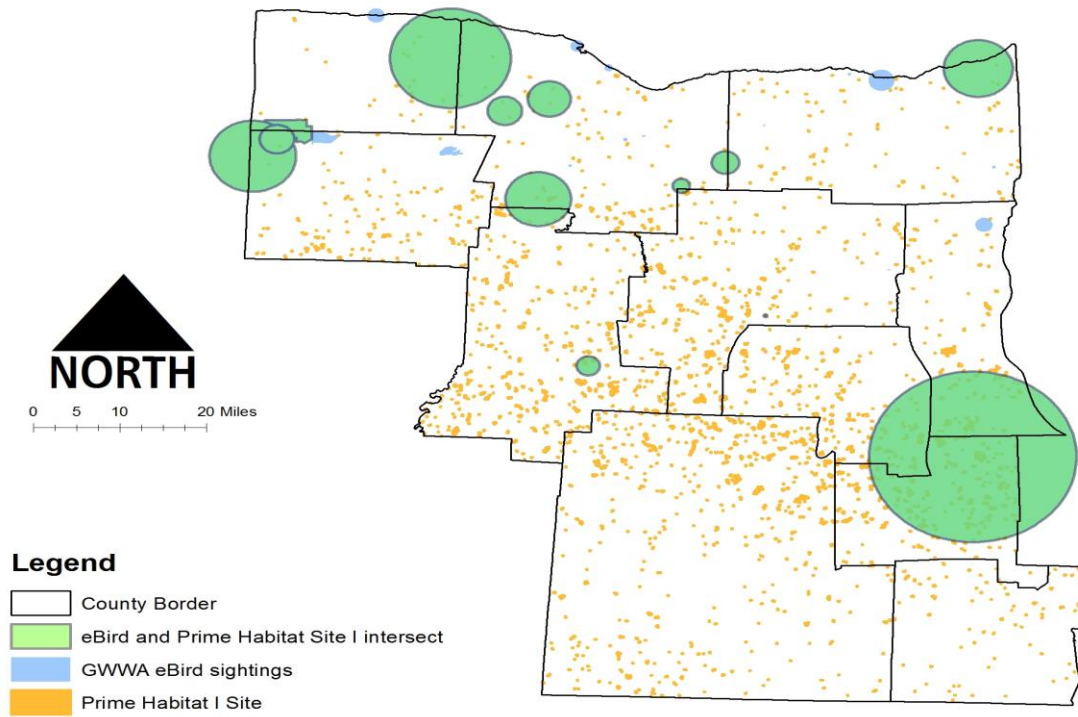


Figure 19a. GWWA eBird sighting intersected with a Prime Habitat I Site.

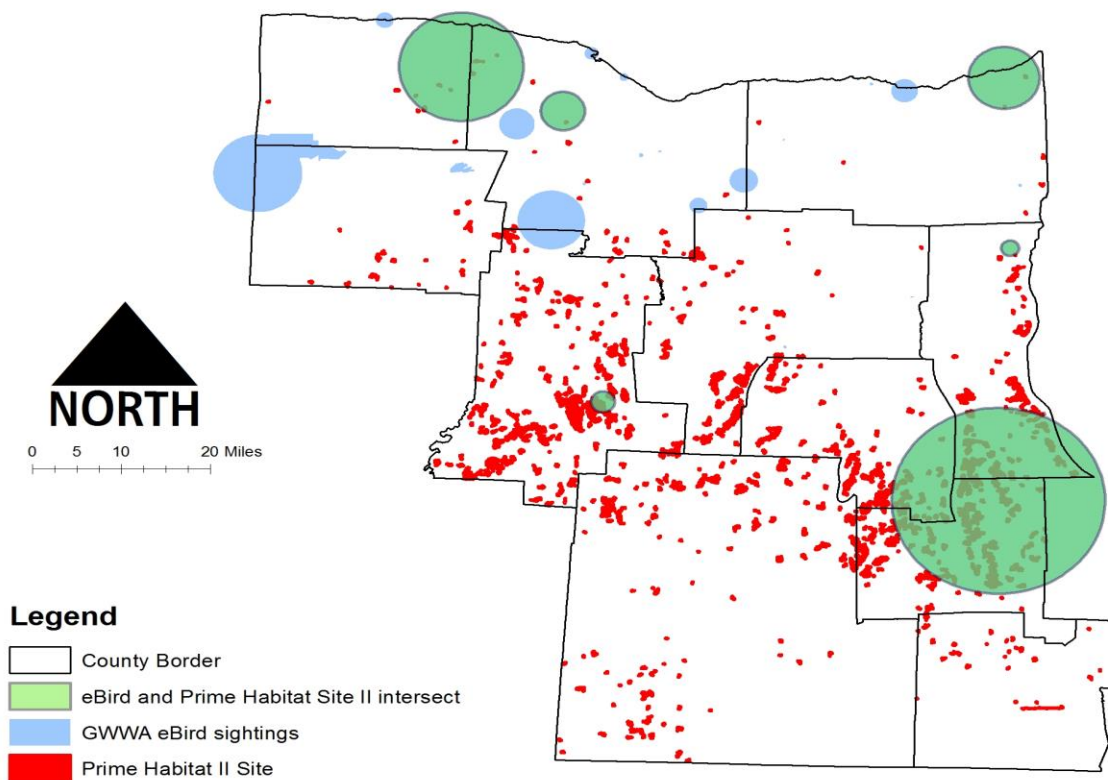


Figure 19b. GWWA eBird sighting intersected with Prime Habitat II Site.

Modified Habitat Sites

GWWA may utilize habitats that do not meet all the land cover requirements that provide a habitat score of 4 (Confer, 2014). Because they may utilize habitats with scores of 3, where forest cover and herbaceous/pasture may be less than ten percent, model qualifications were modified and seed sites with values of 3 or 4 were used for analysis. The modified habitat constraints increase the number of eBird sightings (45 in total) that intersected with seeds sites from 14 to 23 for Prime Habit I Sites, and 8 to 17 for Prime Habitat II Sites. Using these relaxed constraints, the more sparsely distributed habitat in the north did more frequently intersect with eBird sightings, bringing the total number eBird reports that intersected with Prime Habitat I Sites to 51% and 38% for Prime Habitat II Sites (Figure 20a and 20b).

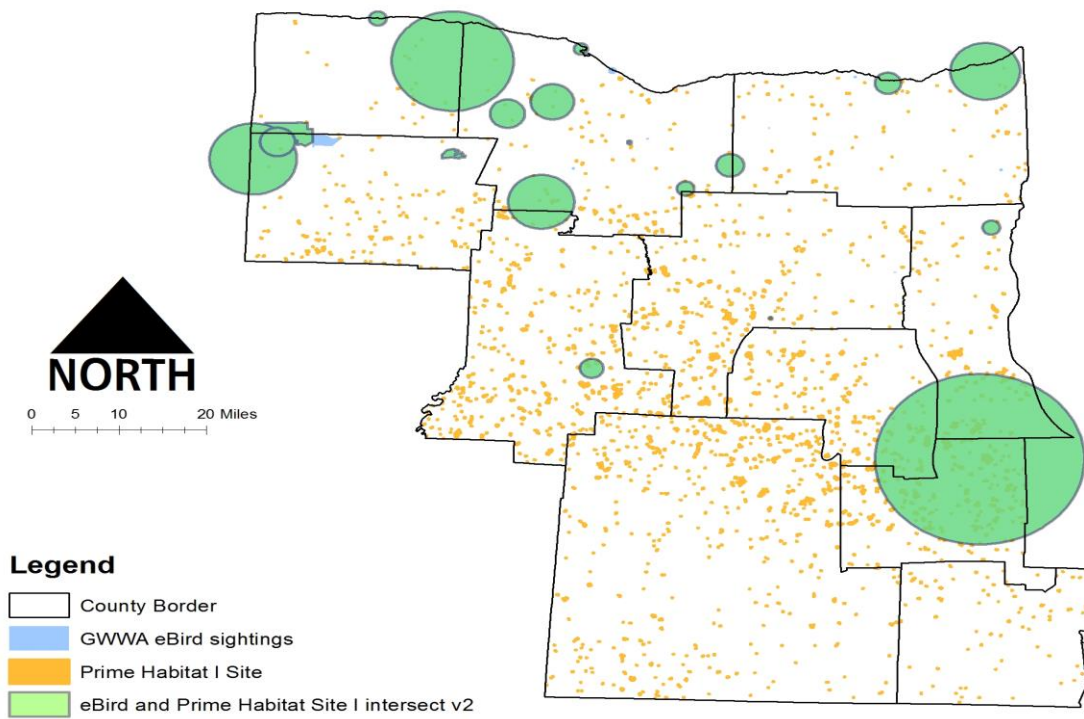


Figure 20a. GWWA eBird sightings intersected with modified Prime Habitat I Sites.

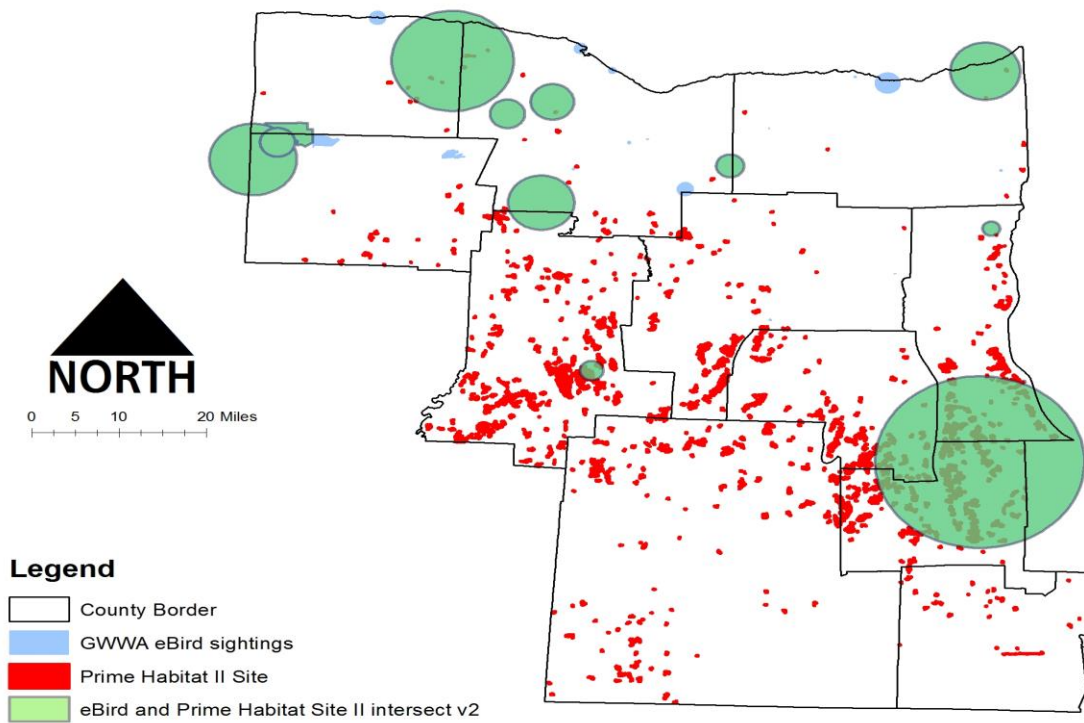


Figure 20b. GWWA eBird sightings intersected with modified Prime Habitat II Sites.

Although modified constraints increased the number eBird reports that intersected with prime habitat, the verification accuracy was still only 38-51%. Based on these results, and to ensure that only the most suitable breeding territory sites were analyzed, the remaining analysis only utilized data for prime sites with habitat values of four, and did not include sites with modified habitat criteria.

Public Land and Management Entities

The private, state, and federal agency parcels used in this analysis account for the managed and public land within the AOI. The datasets used (Figure 21) in this analysis include the Protected Areas Database of the United States Geological Survey (PAD). Parcels listed under the PAD accounted for the most public and protected lands within the AOI. This included national wildlife refuges like Montezuma NWR (an avian hotspot), national forests like Finger Lakes NF, state parks like Watkins Glen SP, and many other protected private and public lands (USGS, 2012).

Aside from PAD, other properties that were utilized included those that belong to the Natural Resources Conservation Service (NRCS), New York State Department of Environmental Conservation (NYSDEC), Real Property Tax Office data for public lands, Finger Lakes Land Trust (FLLT), Genesee Land Trust (GLT), and the Nature Conservancy (TNC). All parcels from these datasets were analyzed to see if the prime habitat sites for GWWA fell within public and managed land boundaries. Overall, there are approximately 1800 parcels within the AOI, totaling an area of 165,798 hectares.

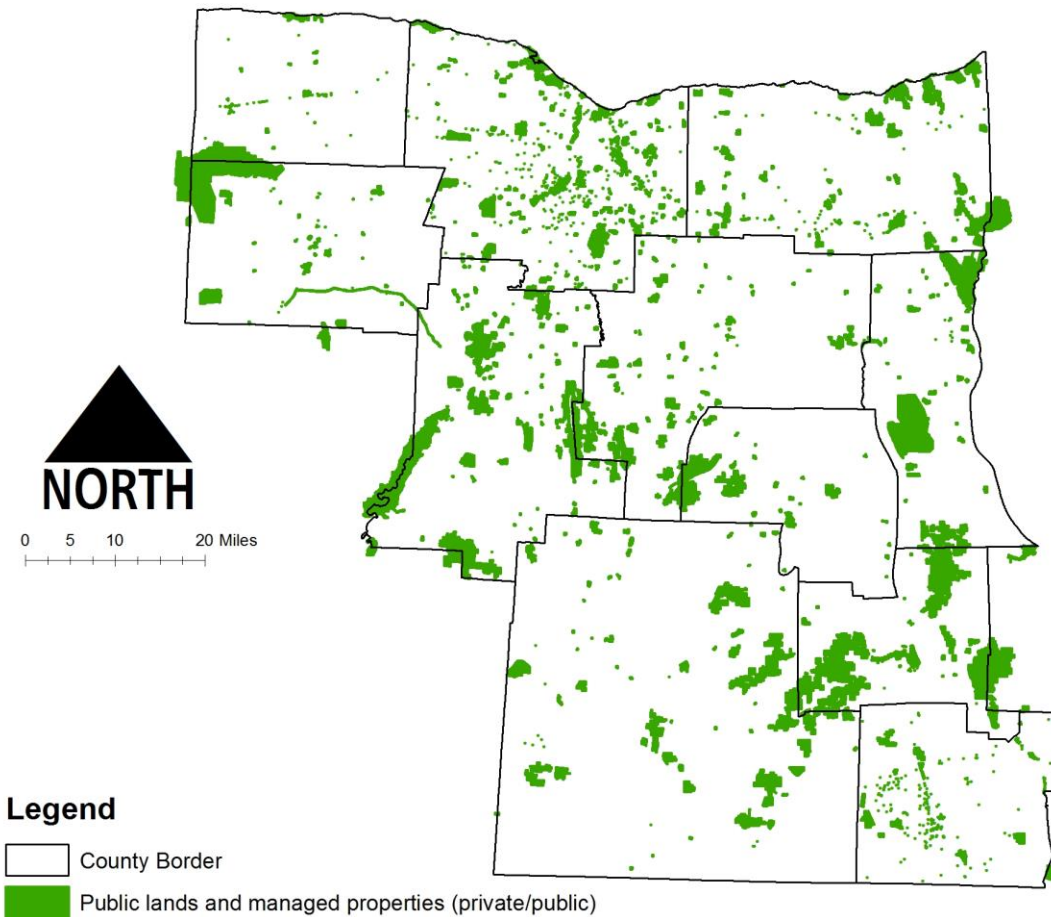


Figure 21. FLLT, GLT, NRCS, NYSDEC, PAD, Real Property Tax Office, and TNC parcels within the Western Finger Lakes District of New York.

These parcels were intersected with Prime Habitat I and II Sites, to see where the concentration of GWWA habitat occurred within the managed parcels. Based on figures 22a and 22b below, the concentration of parcels that intersected with prime habitat sites occurs in the Central Band, with a majority of those properties being NYSDEC or PAD Parcels. 88% of the public and managed lands that intersected with Prime Habitat I Sites were comprised of NYSDEC and PAD listed properties, and 75% for Prime Habitat II Sites. There is also a scattering of parcels with Prime Habitat I Sites within them in Monroe County. Further analysis of these results is addressed in the discussion section.

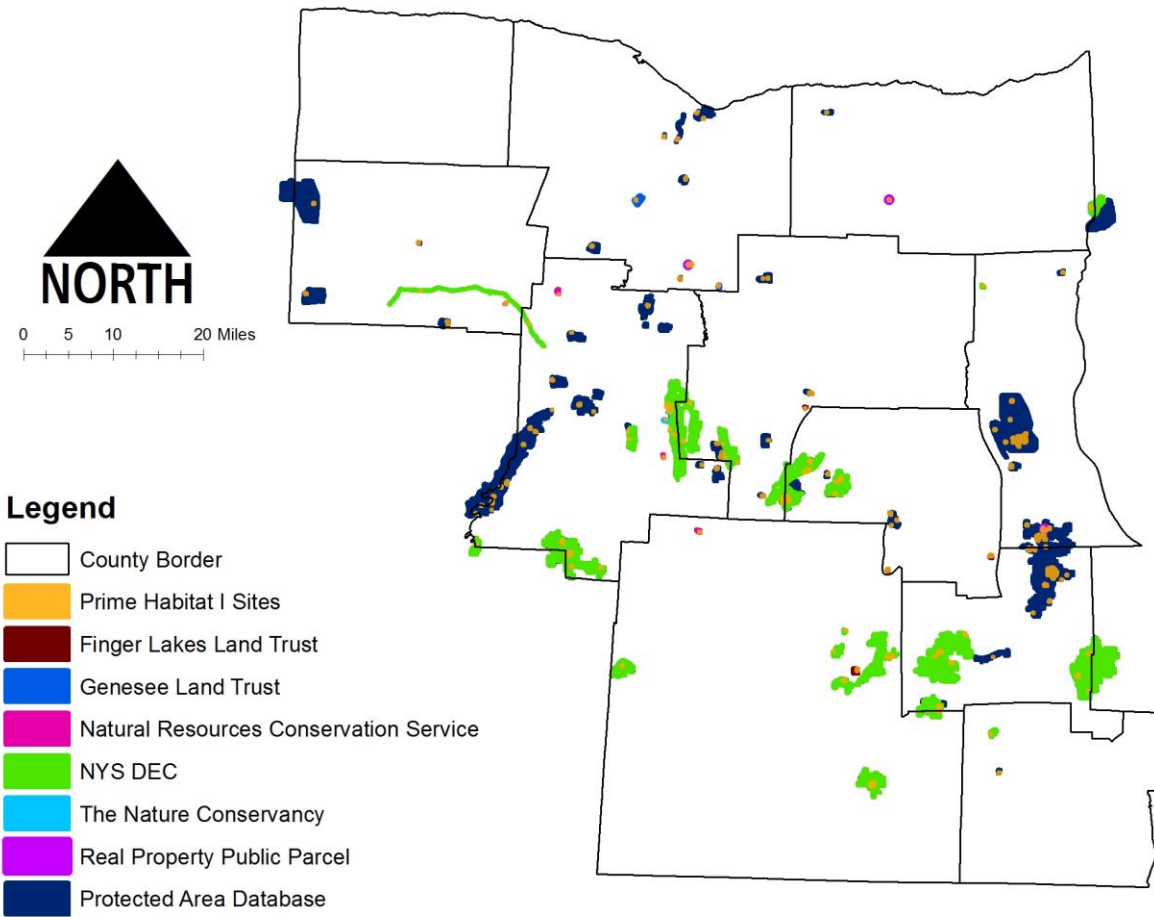


Figure 22a. Prime Habitat I Sites within managed land parcels.

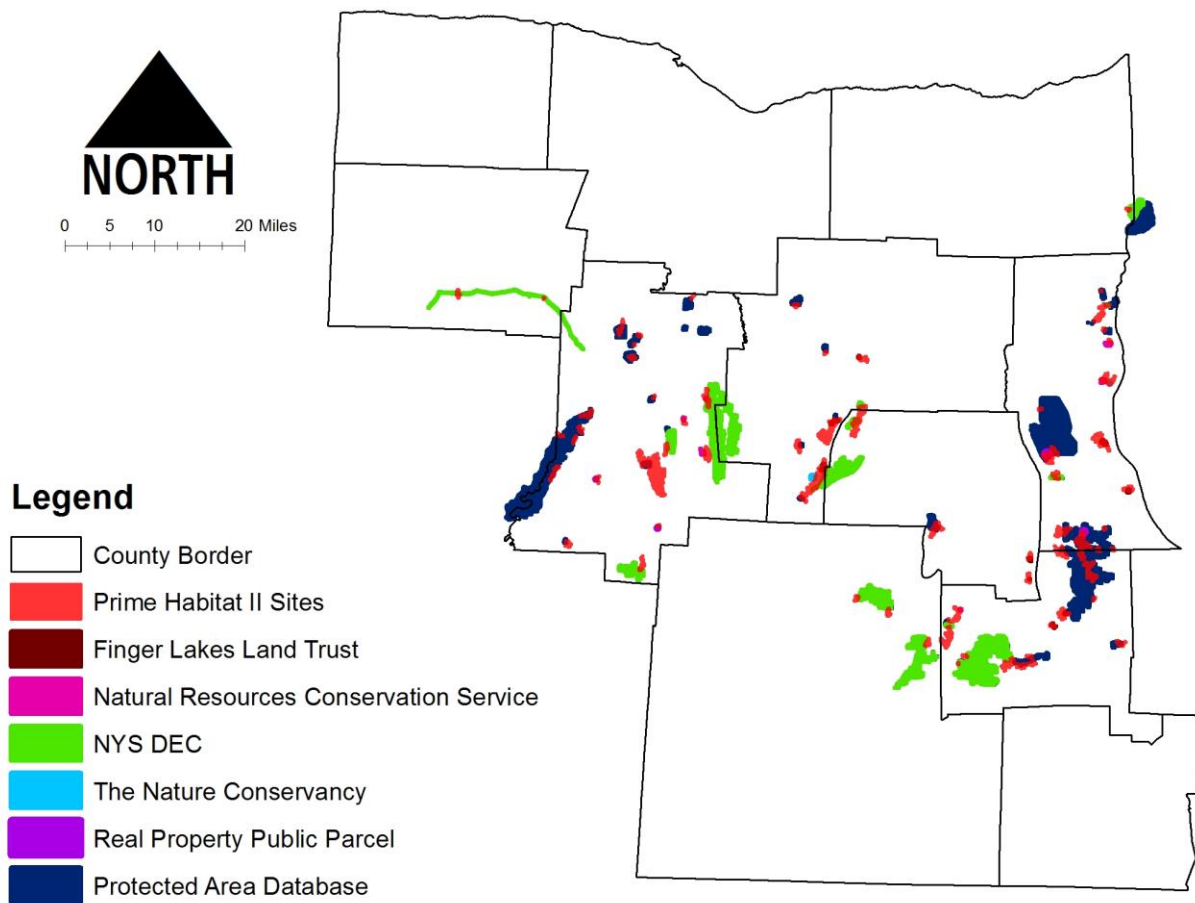


Figure 22b. Prime Habitat II Sites within managed land parcels.

Wildlife Management Areas

NYSDEC's Young Tree Initiative has stated that it will prioritize the creation and management of GWWA habitat and monitoring in Wildlife Management Areas (WMA) across the state. Figure 23 below shows all WMA sites that contain Prime Habitat I and II Sites. The figure also shows all WMA sites that had GWWA eBird Sightings and/or contained Breeding Bird Surveys.

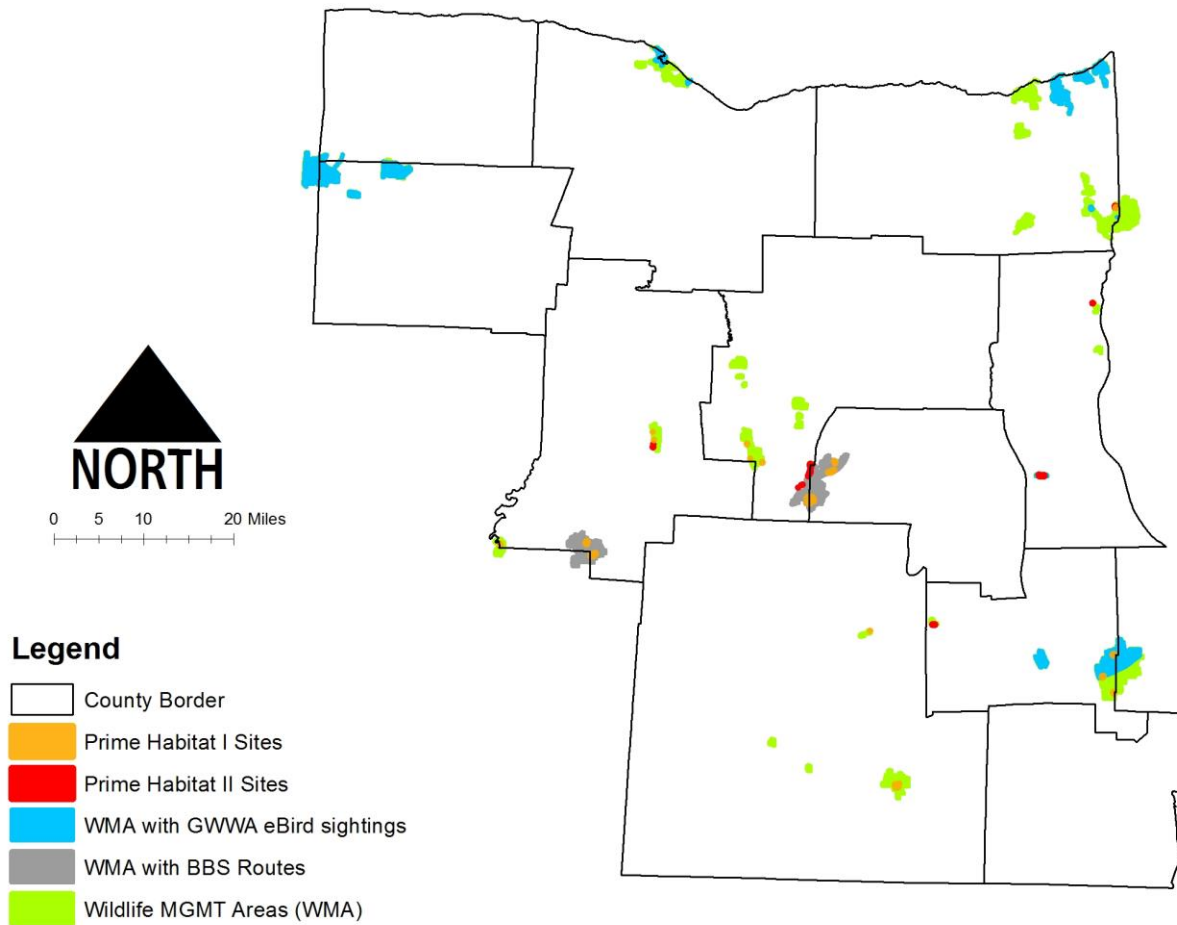


Figure 23. Wildlife Management Areas (WMAs) with GWWA habitat, and/or GWWA eBird sightings, and/or a BBS route.

Table 13 below shows the breakdown of each of these sites in relation to the number of Prime Habitat I and II Sites, eBird sightings, and/or BBS routes it contains. The WMA's listed in Table 13 would all be considered potential areas to implement the NYSDEC's Young Tree Initiative because they contain prime GWWA habitat or have already reported GWWA present from eBird or BBS data. The WMA sites highlighted in red represent likely GWWA presence because of large amounts of nearby GWWA habitat. All highlighted WMA's are in the Central Band except Northern Montezuma WMA.

Table 13. Breakdown of WMA sites. Sites highlighted in red are the most proable areas for GWWA.

WMA Site	Prime Habitat I Sites	Prime Habitat II Sites	County	GWWA eBird Sighting	BBS Route Present	Within Central Band
BRADDOCK BAY	0	0	Monroe	Y	N	N
CATHARINE CREEK	0	0	Schuyler	Y	N	Y
COLD BROOK	1	0	Steuben	N	N	Y
CONESUS INLET	2	1	Livingston	N	N	Y
CONNECTICUT HILL	3	0	Schuyler	Y	N	Y
ERWIN	1	0	Steuben	N	N	Y
GENESEE VALLEY	1	0	Livingston	N	N	Y
HIGH TOR	3	2	Yates	N	Y	Y
HONEOYE INLET	3	0	Ontario	N	N	Y
JOHN WHITE	0	0	Genesee	Y	N	N
LAKE SHORE MARSHES	0	0	Wayne	Y	N	N
NORTHERN MONTEZUMA	1	2	Wayne	N	N	N
OAK ORCHARD	0	0	Genesee	Y	N	N
RATTLESNAKE HILL	3	0	Livingston	N	Y	Y
TONAWANDA	0	0	Genesee / Monroe	Y	N	N
WANETA LAMOKA	0	1	Schuyler	N	N	Y
WILLARD	0	2	Seneca	Y	N	Y

Elevation Data

High elevation areas (above 390 m), where hybridization with Blue-winged Warbler is unlikely, were intersected with prime habitat sites (Bakermans, 2011; Peterjohn, 2006). For Prime Habitat II Sites, 53% fell within high elevation areas. For Prime Habitat I Sites, 45% of the sites were in a high elevation area. The intersecting seed sites were primarily located in the Central Band, where they form a noticeable cluster within areas above 390 m in elevation (Figure 24a and Figure 24b).

Prime habitat sites above 390 m that reported GWWA sightings from eBird and BBS are also identified. Prime Habitat I Sites areas above 390 m that have reported GWWA include sites found on BBS route #61051, BBS route #61052, Finger Lakes National Forest (GWWA eBird sighting present here), and select sites in South Conesus (Figure 24a and Figure 24b).

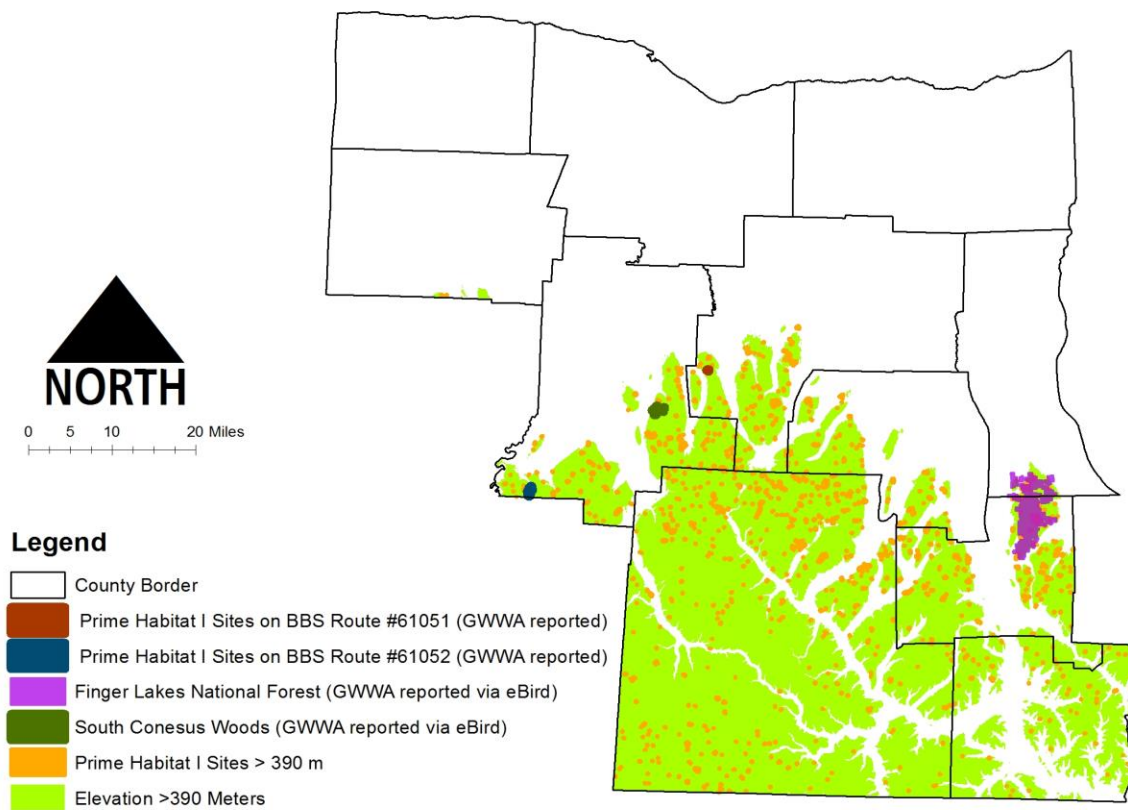


Figure 24a. Prime Habitat I Sites above 390 m that have reported GWWA (eBird/BBS).

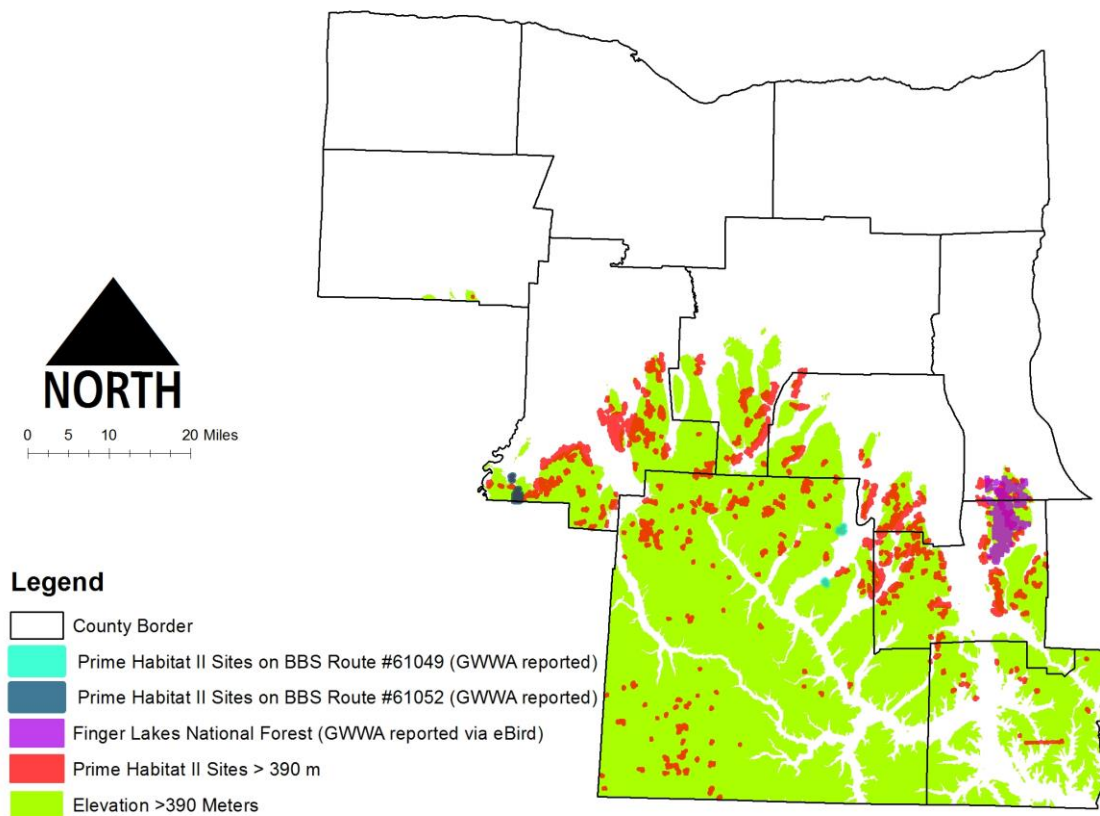


Figure 24b. Prime Habitat II Sites above 390 m that have reported GWWA (eBird/BBS).

DISCUSSION

Sighting Data

BBS Results

BBS data do not record the specific locations of where species were sighted. Instead, surveyors mark species presence along a 24.5 mile route. Because of this, BBS data can be used to broadly identify areas a species utilizes, but not to identify a precise locale. Regardless, BBS data are commonly used by avian researchers because they offer long term (≈ 50 years) and reliable accounts for bird species within a large track of habitat, which remains relatively undisturbed. For a regionally threatened species like GWWA, detection on a BBS route is valuable for researchers looking to decide where to focus resources.

Overall, the model was useful in predicting GWWA's presence within a BBS route. Two-thirds of the routes that have detected GWWA in the last five years contained one or more prime habitat sites. It is recommended that GWWA conservation efforts be focused within any of the BBS routes in Table 14, because they contain prime habitat sites and have previously detected GWWA. If resources need to be focused within one BBS route in particular, route #61052 in Livingston County is a good candidate because it contains the most Prime Habitat I and II Sites within a single route detecting GWWA (Figure 25).

Table 14 BBS routes that detected GWWA and contain prime habitat sites.

<u>Number</u>	<u>Route Name</u>	<u>GWWA Present</u>	<u>Prime Habitat I Site</u>	<u>Prime Habitat II Site</u>	<u>County</u>	<u>Central Band</u>
61049	Branchport	Y	Y	Y	Steuben, Yates	Y
61051	Mendon	Y	Y	Y	Livingston, Monroe, Ontario	Y
61052	Mt Morris	Y	Y	Y	Livingston	Y
61043	Trumansburg	Y	N	Y	Seneca	Y

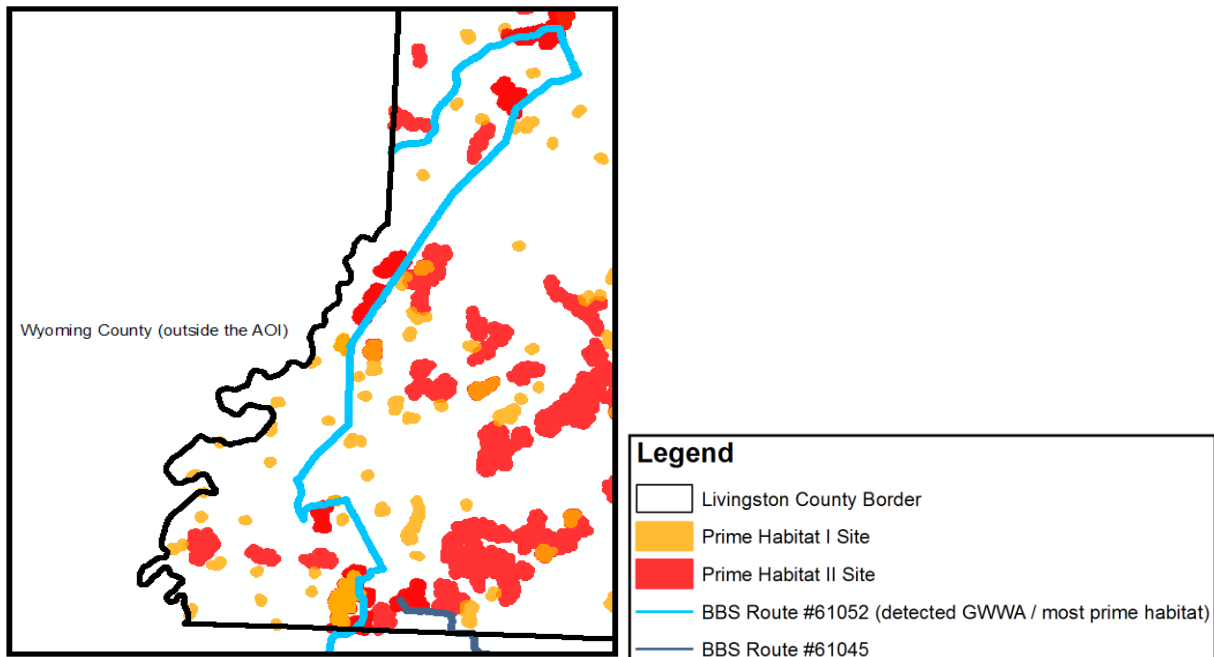


Figure 25. BBS route #61052 in Livingston County, which has the most Prime Habitat I and II sites within a route that has detected GWWA.

Because GWWA is a species of conservation concern in New York, and other bird species of concern utilize similar habitat (i.e. Eastern Whip-poor-will), areas with large amounts of prime habitat that have not previously detected GWWA are also important to identify. Taking this into consideration, there are likely GWWA present in BBS routes with large amounts of habitat sites, even though GWWA may have not been reported within the last five years. This is supported by the model, where eight out of the 13 of routes that did not detect GWWA had both Prime Habitat I and II Sites within the same route, and ten out of the 13 routes that did not detect GWWA contained either Prime Habitat I Sites or Prime Habitat II Sites, but not necessarily both in the same route.

BBS route #61110 in Ontario County (Figure 26) contained the highest number of Prime Habitat I and II sites within a single BBS route. Route #61050 in Ontario contained the second highest number of Prime Habitat I sites within the AOI. Neither of these BBS routes has

detected GWWA within the last five years, but their presence is probable because of the large amount of habitat contained within them, and because of their proximity to route #61051, which has previously detected GWWA.

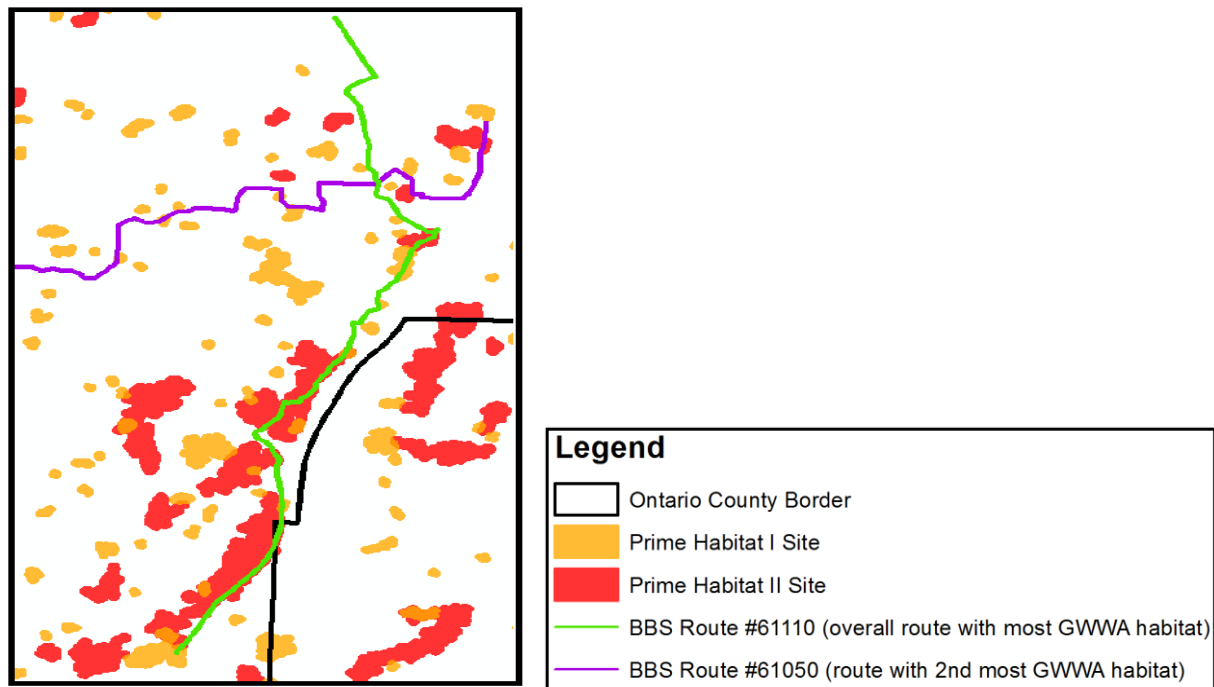


Figure 26. BBS routes in Ontario County that contained the most Prime Habitat I and II Sites within the AOI.

Although BBS routes are generally visited annually, this is not always the case, due to volunteer availability. Because of the number of prime habitat in these routes, it is recommended that BBS prioritize conducting annual surveys in the Ontario routes and prioritizing Golden-winged Warbler as species of interest, along with other vulnerable bird species that utilize GWWA habitat.

Chemung and Schuyler Counties currently do not have any BBS routes within their boundaries. Steuben is the largest county in the AOI and only contains part of a single route (#61049 , which starts in Yates County). This route has previously detected GWWA. These

three counties contain a large amount of potential habitat, so it recommended that BBS routes be considered as additions to these areas, not just to monitor GWWA, but many other shrubland species. Additionally, these three counties have notable amounts of public lands and managed properties (Figure 27), specifically NYSDEC properties, so collaboration between BBS and other managing agencies should be considered to implement routes in these areas. Currently, the United States Geological Survey (which oversees the Breeding Bird Surveys) and NYSDEC already collaborate on other projects like groundwater resource mapping (<http://www.dec.ny.gov/lands/36118.html>) and elevation data mapping (<http://gis.ny.gov/elevation>), so collaboration for this project may be feasible and is recommended.

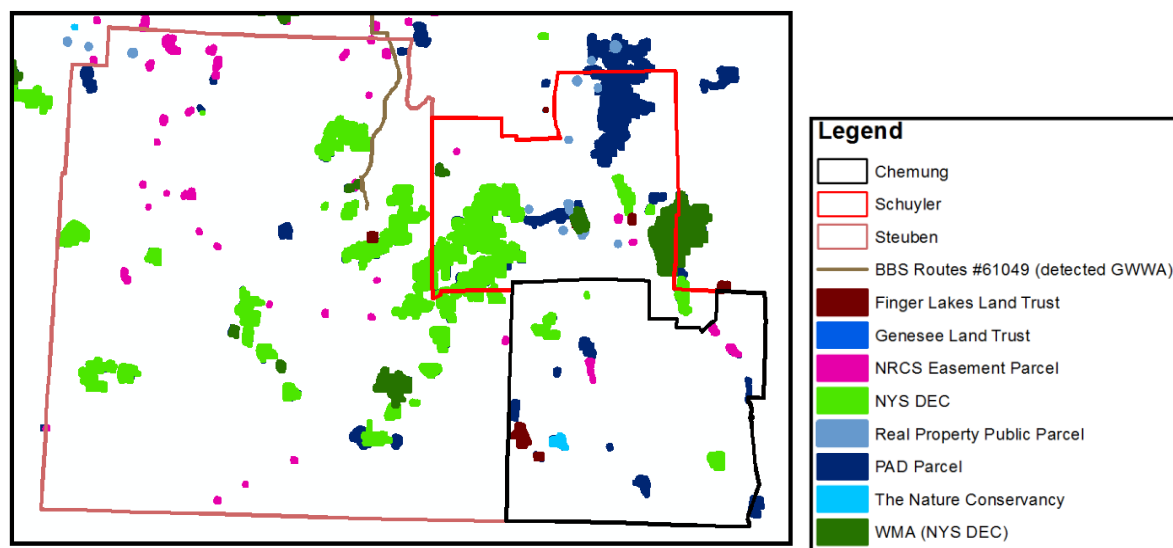


Figure 27. Counties without BBS routes. Steuben contains part of BBS Route #61049 (detected GWWA).

eBird Results

Ontario County reported the most GWWA eBird reports (three) within the Central Band. Two out of the three areas contained Prime Habitat I Sites, with one area containing multiple habitat sites, which is located nearby Bentley Woods Preserve (a TNC property) in the Northwest corner of Ontario County. The sighting area contained two Prime Habitat I Sites, totaling approximately nine hectares. The other eBird sighting area contained one Prime Habitat I Site, 2.4 ha in size, and was located near Bare Hill Unique Area, a property managed by NYSDEC (Figure 28). In addition, this sighting was in close proximity to BBS route #61110, which is the BBS route in the AOI that had the most prime habitat sites, making it one of the most probable locations to find GWWA in the study area. The same analysis was performed for Livingston County, which contains BBS route #61052, which contains the most Prime Habitat I and II sites within a BBS route that has recently reported GWWA.

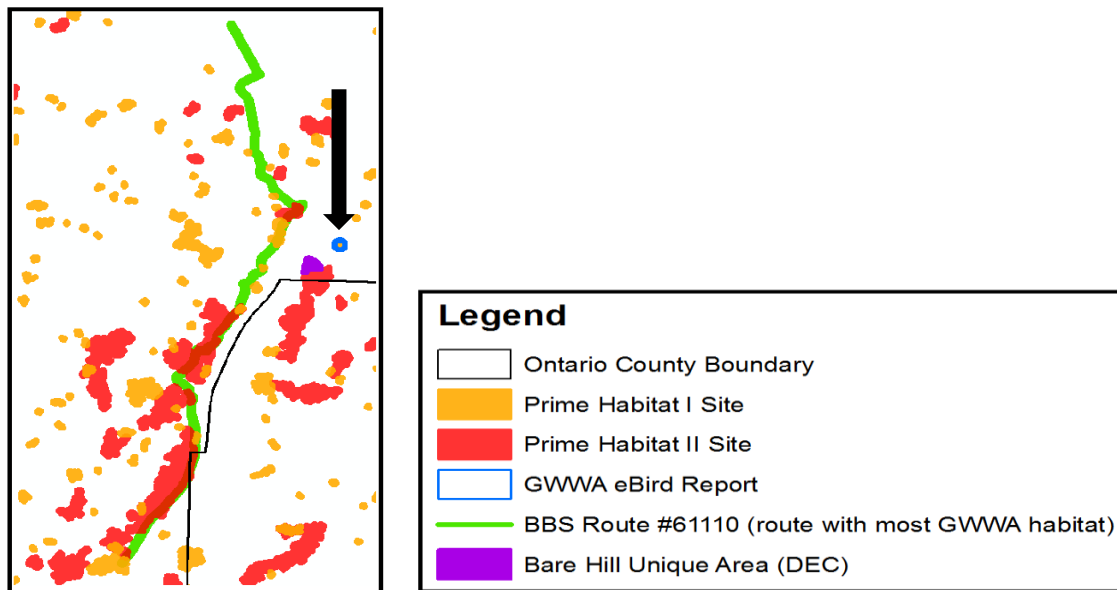


Figure 28. Black arrow pointing to GWWA eBird report location in Ontario County. Location surrounded by prime habitat sites, MGMT areas, and BBS routes that have previously detected GWWA.

The same analysis for an eBird report was performed on Livingston County, because Livingston contains BBS route #61052, which had the most Prime Habitat I and II sites within a route that has recently detected GWWA. Both eBird sightings within Livingston County contained multiple prime habitat sites, with the eBird report in the southern part of the county containing four Prime Habitat I Sites (Figure 29), totaling an area of approximately 57 ha. The same reported area contained four Prime Habitat II Sites, totaling an area of approximately 856 ha. The largest Habitat II Site within this reported area was 482 ha, making it eight times larger than the average Prime Habitat II Site in the AOI. The eBird reported area here had no managed properties within it, but it was in close proximity to Conesus Inlet WMA and Hemlock-Canadice State Forest, both NYSDEC properties. Also passing through Hemlock-Canadice State Forest is BBS route #61051, which has previously detected GWWA.

The other eBird report in Livingston County contained five Prime Habitat I Sites (Figure 29), totaling approximately 19 ha in area, with no Prime Habitat II Sites. The largest Prime Habitat I Site here was approximately 22 ha, making it three times larger than the average Prime Habitat I Site within the AOI. This report did have managed properties within the sighting area, specifically: Caledonia Fish Hatchery (NYSDEC), Christine Sevilla Wetlands Preserve (Genesee Land Trust), Washburn Municipal Park, and three conservation easements on private lands.

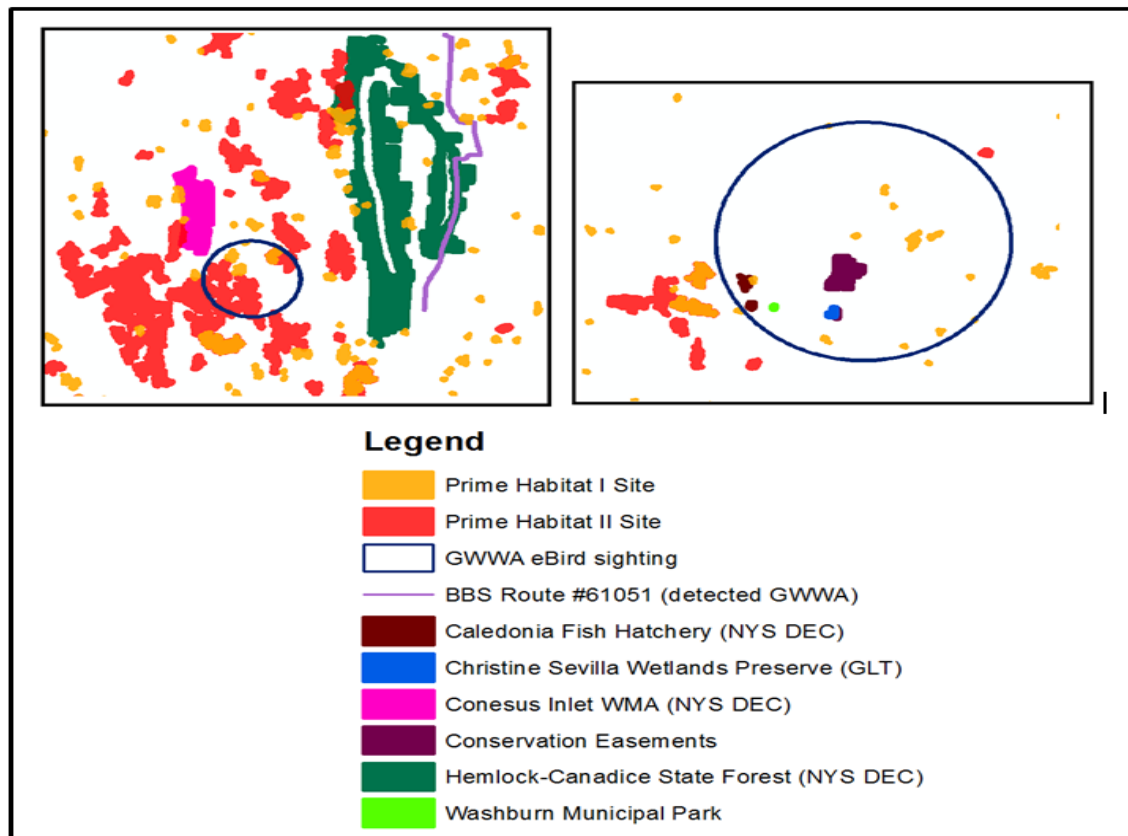


Figure 29. *Left:* GWWA eBird report in the southern part of Livingston County. *Right:* GWWA eBird report in the northern part of Livingston County.

This same analysis was also performed within the eBird report that surrounded the Finger Lakes National Forest (Seneca and Schuyler County), which is the southernmost sighting for GWWA within the AOI. This report was chosen for analysis because it had the largest number of prime habitat sites within any eBird reports in the AOI, with 21 Prime Habitat I Sites (totaling 453 ha), and 22 Prime Habitat II Sites (totaling 1872 ha). The largest Prime Habitat I site here was approximately 117 ha, making it almost 16 times larger than the average Prime Habitat I Site within the AOI. The largest Prime Habitat II Site was 263 ha, which is more than four times larger than the average Prime Habitat II Site within the AOI. These results may be skewed by the large area covered within this eBird report. It was much larger (12 square miles) than other

eBird reports in the AOI, which could help account for the large amount of habitat contained. The report from the Finger Lakes National Forest location also contained BBS route #61043, which has previously detected GWWA (Figure 30).

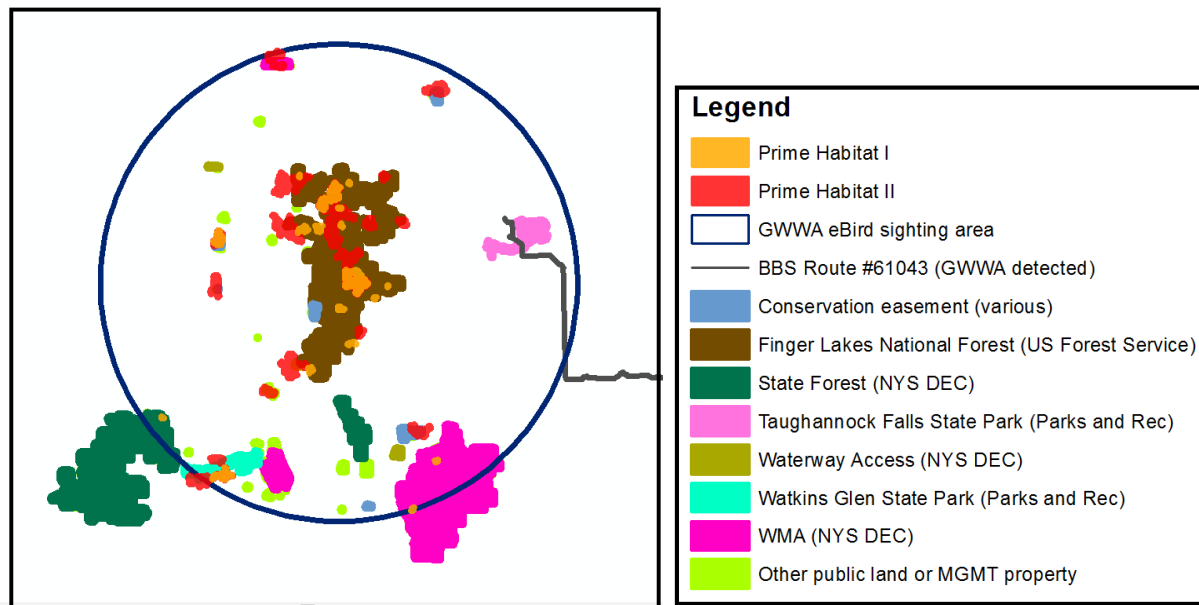


Figure 30. *Left:* GWWA eBird report in the Finger Lakes National Forest area (Seneca and Schuyler County).

The eBird reports in the Central Band discussed above (Finger Lakes National Forest, Ontario County, and Livingston County) were all indicators of the presence of GWWA habitat, suggesting the model may be effective in predicting the presence of GWWA through use of eBird data. Overall though, there were much fewer eBird reports in the Central Band than counties in the north, where predicted GWWA habitat was less abundant. This made using eBird for broad scale model validation challenging, since overall one-third of all eBird reports in the AOI contained Prime Habitat I Sites, and approximately one-fifth of the reports contained Prime Habitat II Sites. The lack of uniform eBird reporting across counties may spatially bias against counties with fewer birders but more abundant habitat.

The counties with the highest concentration of GWWA eBird reports all border Lake Ontario, including Monroe County (19 GWWA sightings), Wayne County (11 sightings), and Orleans County (9 sightings). The lake fronts of all three of these counties are favored stop over sites for migrating passerines. The high number of GWWA sightings here is likely attributed to stop-over birds, passing through while traveling to their breeding grounds. Additionally, stop-over sites along the lake front are popular with bird watchers, which would also account for greater eBird coverage and reports. Although the seasonal filter was used to account for breeding versus non-breeding birds, it may not be effective in separating the two, reducing the reliability of these data parameters for the model verification process.

The lack of sightings in the Central Band could be attributed to fewer bird watchers in the area, who may choose to travel to popular nearby lake front locations like Braddock Bay, a birding hot spot. Other reasons may include inaccessibility in areas with large amounts of private lands, which is discussed more in the Conservation Easements analysis below.

Another likely cause for small numbers of reports include small human populations in the counties that make up the Central Band. This conclusion is supported by Table 15 (eBird Raw Data, 2014; US Census, 2010), which shows the number of submitted eBird checklists over time in a specific county versus the same county's human population. Yates had 25,208 people as of 2014 and has 2754 checklists reported on eBird (highlighted in red), compared to Monroe County, which had 749,857 people in 2014, with 54,376 checklists reported on eBird (highlighted in red). Although Yates has a higher ratio of people versus number of checklists submitted compared to Monroe (11% vs. 7%), the number of total submitted checklists (sighting data) is still much lower for Yates, likely due to a smaller human population.

Seneca County (highlighted blue) is an anomaly because it has a small human population, but has the second highest number of checklists submitted in the AOI. This could be attributed to Seneca Counties' close proximity to Tompkins County, which is where Cornell University and the eBird team are physically located. Tompkins County likely has more checklists than any other county in New York State because of Cornell's presence.

Table 15. Number of eBird checklists per county versus human population. Counties highlighted in red illustrate the significant range in number of submitted eBird checklists. Seneca County, highlighted in blue, is an anomaly, presumably due to its proximity to Cornell University and the eBird program team.

<u>County</u>	<u># of Checklists</u>	<u>2014 Census Population</u>	<u>Central Band</u>
Chemung	14554	87770	N
Genesee	6905	59162	N
Livingston	12910	64586	Y
Monroe	54376	749857	N
Ontario	22390	109707	Y
Orleans	5026	41984	N
Schuyler	3204	18479	Y
Seneca	30674	34884	Y
Steuben	7331	98394	Y
Wayne	21671	92051	N
Yates	2754	25208	Y

Based on the eBird data, species like GWWA may not appear to be abundant in the Finger Lakes Region, even though GWWA habitat is present. It is difficult to test whether or not this statement is true because there is an abundance of reports (for all species) in the northern counties, where GWWA habitat is less abundant, and a lack of reports in the southern counties. This uneven distribution of data across the AOI can cause a spatial bias when assessing the abundance of a bird species (Kelling, 2013), so caution should be taken with these results until greater coverage is available.

In an effort to mitigate potential spatial bias, eBird is trying to increase their overall coverage in under reported areas. Cornell started a program in 2016 called eBird Avicaching (ebird.org/content/ebird/avicaching) to incentivize its users to submit checklists in under reported locations, like those in the Central Band, in an effort to increase overall coverage and improve the presence/absence confidence of species in underexplored areas (eBird, 2012). The avicaching program utilizes bird watching with geocaching. Geocaching is an outdoor activity where people go to specific sites to look for various small treasures (eBird, 2012). In this program, users are awarded points in a competition, with the value depending on how many checklists they submit in under birded areas. The fewer historical checklists a location has, the more points it is worth, meaning the less visited a place is, the higher the overall value. For each point you earn, you are entered to win a free \$1000 Zeiss Binocular give away, with no limitation on the number of times you can be entered (100 points equals 100 entries). There is also a separate competition for the user who sees the most bird species in these Avicaching locations. As of September 2016, there is no prize for this category, but this is a new program and there may be one in the future (eBird, 2012).

As of September 2016, Avicaching locations have only been implemented in Tompkins County, where Cornell Lab of Ornithology is located, and surrounding counties Schuyler and Cortland. Schuyler County is in the AOI, within the Central Band, and contains multiple prime habitat sites, and is one of the areas being implemented for Avicaching. The areas in Schuyler that are being used for Avicaching are Sugar Hill State Forest and Goundry Hill State Forest (Figure 31). Although the eBird Avicaching program is not specifically aimed at finding GWWA, it is encouraging users to look in areas with the most GWWA habitat, like Schuyler County. It is possible that more GWWA, and other species of conservation concern, may be

identified in the future as a result of this new program, making future use of eBird results more effective for broad scale implications on species absence/presence.

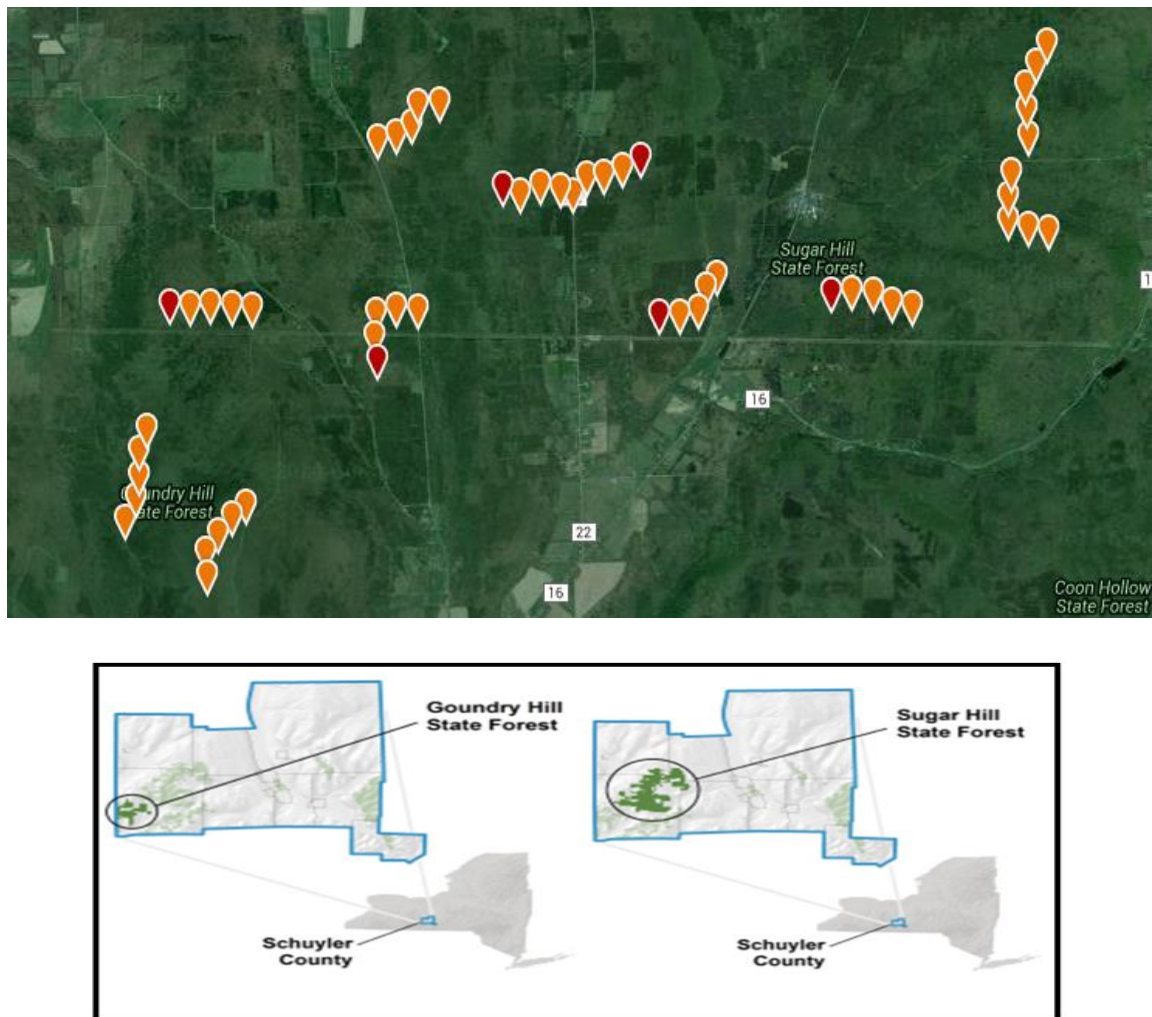


Figure 31. *Top:* eBird Avicaching locations in Schuyler County (<http://ebird.org/ebird/avicache/home>). *Bottom:* DEC maps of forest locations (<http://www.dec.ny.gov/lands/37437.html>; <http://www.dec.ny.gov/lands/37446.html>).

Land Management Entities

The concentration of managed properties that intersected with prime habitat sites occurs in the Central Band on NYSDEC and PAD parcels, where 88% of their properties contained Prime Habitat I Sites (Figure 22a), and 75% contained Prime Habitat II Sites (Figure 22b). This means that Wildlife Management Areas (WMA) managed by the NYSDEC have the potential to contain large amounts of GWWA habitat, as compared to other land management entities in the AOI. The Department of Environmental Conservation's Young Tree Initiative prioritizes the creation and management of GWWA habitat and monitoring in WMAs across the state. Seventeen WMAs were present in the AOI, which could potentially support GWWA. Overall, the WMA most likely to contain GWWA are High Tor (Yates and Ontario County), which contained the highest amounts of Prime Habitat I and II Sites (Figure 32). It was also one of two WMAs in the AOI that intersected with a Breeding Bird Survey route. Specifically, route #61110, which is one of the most probable sites within the AOI for GWWA and also has a nearby GWWA eBird report.. Rattlesnake WMA in Livingston and Allegany counties (outside AOI) also had a BBS route running through the property boundaries (Figure 32). From the earlier BBS route analysis, the routes that run through these WMAs and nearby are the same BBS routes that contained the most prime habitat overall.

Monitoring GWWA and other Young Tree Initiative target species that share GWWA habitat (American Woodcock, Eastern Whip-poor-will, and New England Cottontail) in WMA sites with prime habitat like High Tor and Rattlesnake may be easier than within other WMAs, since BBS routes are already operating within them and actively searching for these species.

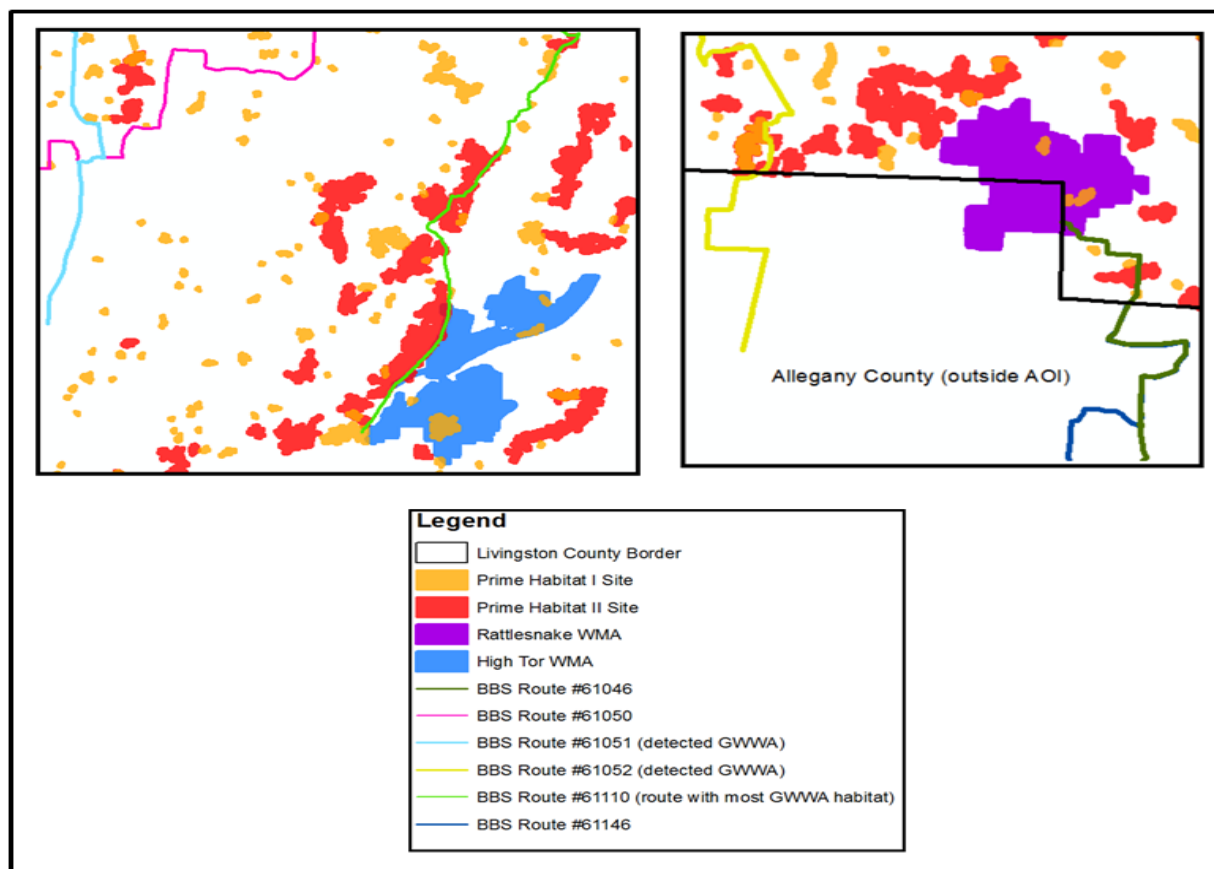


Figure 32. NYSDEC Wildlife Management Areas with the most prime habitat and containing a Breeding Bird Survey Route. *Left:* Ontario and Yates County (High Tor WMA); *Right:* Livingston County (Rattlesnake WMA).

Conservation Easements

Difficulty in creating a comprehensive GWWA management plans has arisen because of the impediment of enacting management practices on private property (Thogmartin and Rohweder, 2009). This study identified GWWA habitat on both private and public lands. Figure 33 shows prime habitat sites that fall between public lands/managed parcels. The sites that fall within the managed property gaps are potentially unprotected areas, which could lead to potential issues of future for GWWA habitat loss from human development on unprotected lands.

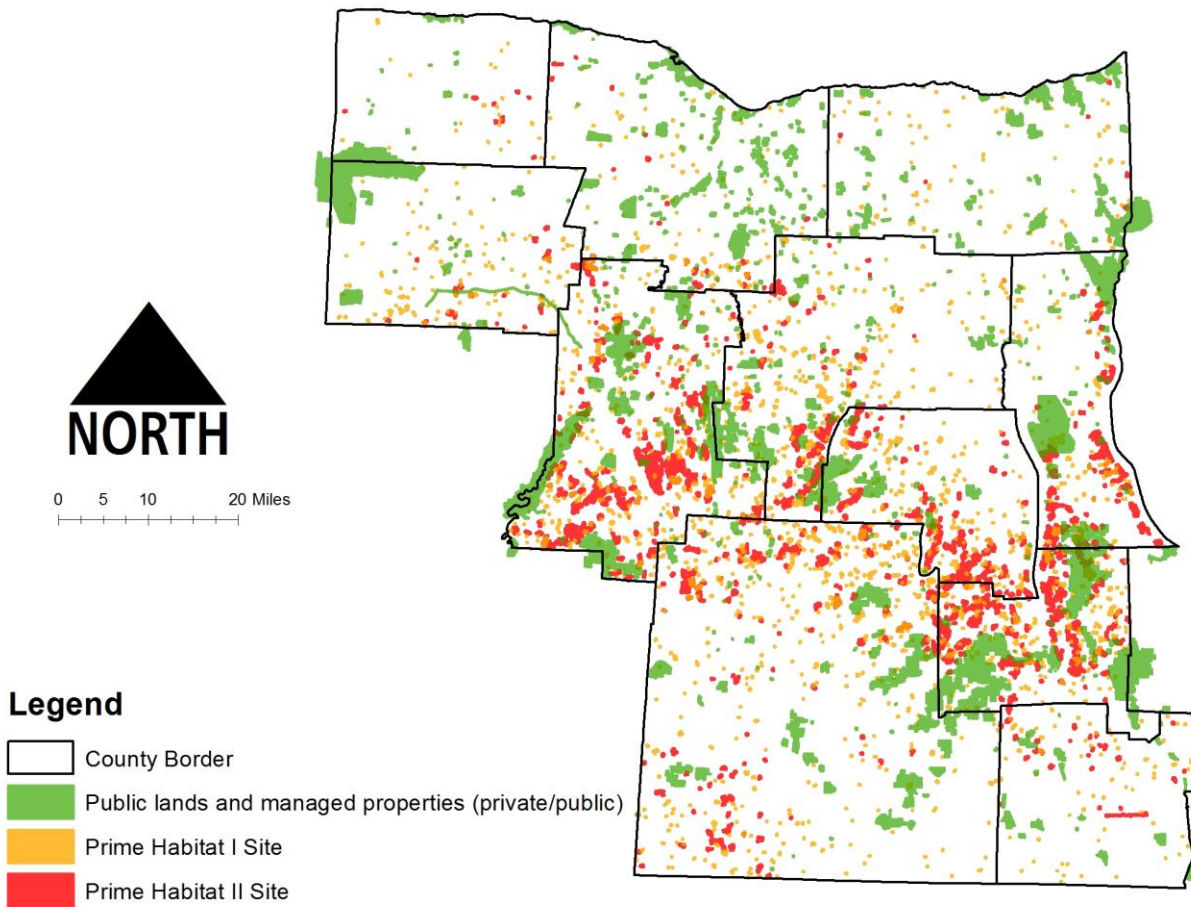


Figure 33. Potentially unprotected prime habitat sites that fall between public lands/managed properties in green (FLLT, GLT, NRCS, NYSDEC, PAD, Real Property Tax, and TNC parcels).

Northeastern shrublands represent some of the most rare habitat types in the United States, and their loss impacts not only GWWA, but other species that rely on this ecosystem. Conservation easements offer a potential option for providing long term conservation of private shrublands within the AOI that are not currently managed for wildlife (Brenner et al., 2013). Under conservation easements, a legal agreement between the land owner and land management agency is created, outlining what development activities can be conducted on the land (Carson, 2015). Conservation easements do not restrict land owners from using or developing their lands (i.e. farming, timber). Instead, they work towards a conservation goal, such as protecting certain

patches of shrublands in an area, allowing the land owner to either farm or harvest timber on other patches, sometimes utilizing a rotating schedule based on the number of years since harvest. In addition, the land owner is usually offered a tax break or fee for the exchange (Fishburn et al., 2009). The Nature Conservancy is one of the largest overseers of protected lands in the country and within the AOI, and currently utilizes conservation easements to obtain about three quarters of their new land acquisitions (Brenner et al. 2013, Fishburn et al., 2009). Conservation easements would help address the issues that arise when trying to protect declining habitats, like northeastern shrublands, on private lands. Conservation easement strategies integrate the needs of the land owner and the land trust agency, and they do not require large fees to buy the land outright, making them a popular means for conservation (Fishburn et al., 2009; Wallace et al., 2008).

Range in Size of Prime Habitat Sites

Typical breeding territory for GWWA range in size from 0.4 to 6.0 hectares. For the identified Prime Habitat I Sites, approximately 70% of the sites were under 6 ha. This is valuable, because it means that a majority of these sites are within the range of size utilized by GWWA for breeding territory.

The highest concentration of Prime Habitat II Sites (22 sites) are approximately 13-14 ha in size, an area closer in size to a typical GWWA home range of ten hectares. Previous studies have suggested managing GWWA sites at least ten hectares in size (Dettmers, 2003; Confer, 1992). GWWA management plans have also made similar recommendations, but only when there is no other suitable habitat within one mile of the management site (Roth et al., 2012). The

larger Prime Habitat II sites should be considered for land managers looking to manage GWWA home ranges versus breeding territories.

Although these studies have suggested managing larger tracts of GWWA habitat, smaller plots of GWWA habitat are important to identify, in part, because there is an absence in agreement on the minimum patch size needed for many shrubland species, and early successional habitat as small as one hectare can provide adequate habitat for a majority of shrubland birds (Buffum et al., 2014; Askins et al., 2012). These smaller sites can be co-managed for GWWA and other species such as American Woodcock (*Scolopax minor*) and Ruffed Grouse (*Bonasa umbellus*) (both threatened in New York). Smaller areas of shrubland are also easier to manage, create, and/or obtain than larger tracts of land. Many land owners interested in promoting shrubland habitat for birds are often not able to/are reluctant to create patches larger than one hectare in size (Buffum et al., 2014). Smaller areas offer a more reasonable solution to this dilemma for landowners who are considering a shrubland for restoration or conservation. In the Central Band, where the concentration of GWWA habitat is present, a corridor of GWWA habitat exists because of the abundance and close proximity of Prime Habitat I Sites (smaller sites) from one another (Figure 13). Smaller sites are easier to manage/obtain, and as shrublands continue to decrease in the Northeast, it is recommended that land managers identify and manage smaller patches of GWWA habitat, in addition to larger plots.

Elevation Data

GWWA researchers have called for ways to manage for habitat segregation between GWWA and Blue-winged Warbler, two closely related species, because of the issue of hybridization (Dettmers, 2003). GWWA habitats in higher elevations have been linked to

decrease in BWWA/GWWA hybridization, where BWWA are less likely at higher elevations (Bakermans, 2011; Peterjohn, 2006). However, there is a lack of consensus on whether elevation is a deciding factor for GWWA habitat selection. Because of this, elevation was not used as iteration criteria when picking prime habitat sites, but instead was broadly analyzed.

Elevation analysis revealed approximately half of the Prime Habitat I and II sites are located at elevations above 390 m. Northeastern shrublands found in high elevations can outlive those found in lower elevations (DeGraaf and Yamasaki, 2003; Latham, 2003), which could account for the large amount of prime habitat sites at this elevation. The location of prime habitat sites above 390m that have detected GWWA in the past could be useful for future researchers looking for locales to investigate GWWA/BWWA hybridization rates at high elevations. High elevation sites that meet this criteria are located within BBS routes #61051 and #61052, and eBird reports for the Finger Lakes National Forest and select sites in South Conesus (Figures 24a and 24b).

FUTURE STUDIES

Absence/Presence of Other Shrubland Birds

Other bird species of conservation concern that utilize similar habitat to GWWA includes American Woodcock (*Scolopax minor*), Eastern Whip-poor-will (*Caprimulgus vociferus*), and Ruffed Grouse (*Bonasa umbellus*). The methodology used for this study could be applied to test for the presence/absence of these species. Specifically, by utilizing BBS and eBird data for these species, their presence or absence in GWWA prime habitat sites could be tested. Information on locations for seed sites that contain all the species above could prove useful for managing entities like NYSDEC and the Young Tree Initiative, which aims to protect these species, as well as GWWA. Alternatively, these methods could be used to test for the presence/absence of species that outcompete and hinder GWWA populations. This includes Blue-winged Warbler (hybridization) and Brown-headed Cowbird (nest parasitism). Prime GWWA habitat sites with high presence of these species should not be considered beneficial for GWWA. Aside from testing presence/absence of all of the species mentioned above through the use of sighting data, it is recommended they should be considered target birds for any point counts conducted (discussed below).

Point Counts

Due to the limited scope of this study, traveling to the seed sites to search for GWWA was not feasible, but a future point count study could be useful to test for presence/absence of GWWA in the prime habitat sites. Point counts are one of the most common methodologies used in avian ecology to survey birds, offering researchers a relatively low cost technique for

testing presence/absence of a species (Matsuoka et al., 2014; Royle et al., 2003). The method involves having trained observers stationed at a specific location for a fixed period of time, where they write down target species/all species seen, within a fixed/unlimited distance from the point (Matsuoka et al., 2014; Ralph et al., 1995).

Point counts should be conducted in the morning, utilize a species search radius of 100m from the point, and be at least 250m from another point. Around 30-50 randomly selected points should be picked to prevent any spatial bias (Royle & Nichols, 2003; Ralph et al., 1995), but depending on how large the site is (i.e. Finger Lakes National Forest), and because GWWA is a relatively rare species in the AOI, more than 30-50 points may be needed. Sites should be visited 10-15 times throughout the breeding season, if possible, but previous GWWA point count studies have visited sites only two times throughout the season (McNeil, 2015; Royle & Nichols, 2003; Ralph et al., 1995). Ultimately, details about the size of the sites chosen and sampling design should be decided by the researcher based on funding, number of participants, and time constraints (Hayes et al., 2015). For more details on conducting point counts, the 1995 technical report “Managing and monitoring birds using point counts: Standards and applications” is a beneficial source (Ralph et al., 1995).

Aerial Photography

A future study looking at aerial images of the prime habitat sites could be useful to see if the prescribed habitat criteria match up with the actual imagery (McNeil, 2015). Approximately 40-60 randomly selected sites should be selected to compare against aerial photography (McNeil, 2015; St-Louis et al., 2006). If the aerial photography shows the same habitat as the model predicted, it could be indicative that other seed sites not compared may likely be accurate.

Absence/Presence of Plant Species

Table 16 shows what species of plants GWWA utilizes within New York and surrounding states (Roth et al., 2012; Bakermans et al. 2011). A potential future study could utilize plant species distribution data from the Geosciences and Environmental Change Science Center (GECSC): Tree Species Distribution Maps for North America (<http://esp.cr.usgs.gov/data/little/>) and USGS National Gap Analysis Program Data (<http://gapanalysis.usgs.gov/gapland-cover/data/download/>), to see if the corresponding plant species from Table 16 are present within the final seed sites. Like the eBird and BBS results, presence/absence modeling can help verify the accuracy of the model. Seed sites that contain all or some of the plant species below might indicate whether a site has GWWA present.

Table 16. Northeastern plant species utilized by GWWA.

<u>LATIN NAME</u>	<u>COMMON NAME</u>	<u>LAND CLASSIFICATION</u>	<u>FOOD</u>	<u>COVER</u>	<u>NEST</u>
<i>Abies balsamea</i>	balsam fir	Coniferous	Y	Y	N
<i>Acer rubrum</i>	red maple	Deciduous	Y	Y	N
<i>Betula papyrifera</i>	paper birch	Deciduous	Y	Y	N
<i>Comptonia peregrine</i>	sweetfern	Shrub	Y	Y	Y
<i>Elaeagnus umbellata</i>	autumn olive	Shrub	Y	Y	Y
<i>Larix laricina</i>	tamarack	Coniferous	Y	Y	N
<i>Lonicera japonica</i>	honeysuckle	Shrub	Y	Y	Y
<i>Picea glauca</i>	white spruce	Coniferous	Y	Y	N
<i>Pinus banksiana</i>	jack pine	Coniferous	Y	Y	N
<i>Pinus resinosa</i>	red pine	Coniferous	Y	Y	N
<i>Pinus strobus</i>	eastern white pine	Coniferous	Y	Y	N
<i>Populus balsamifera</i>	balsam poplar	Deciduous	Y	Y	N
<i>Populus grandidentata</i>	big-tooth aspen	Deciduous	Y	Y	N
<i>Populus tremuloides</i>	quaking aspen	Deciduous	Y	Y	N
<i>Prunus serotina</i>	black cherry	Deciduous	Y	Y	N
<i>Quercus macrocarpa</i>	bur oak	Deciduous	Y	Y	N
<i>Quercus rubra</i>	northern red oak	Deciduous	Y	Y	N
<i>Rosa multiflora</i>	multiflora rose	Shrub	Y	Y	Y
<i>Rubus fruticosus</i>	blackberry	Shrub	Y	Y	Y
<i>Rubus idaeus</i>	raspberry	Shrub	Y	Y	Y
<i>Vaccinium boreale</i>	blueberry	Shrub	Y	Y	Y

CONCLUSIONS

GWWA is currently listed by the International Union for the Conservation of Nature as a globally near threatened species (BirdLife International, 2012), whose international populations have decreased by approximately two-thirds since the 1960s, and whose New York populations have decreased by more than half since the 1970s. GWWA appeared in New York in the mid-1800s in recently abandon farm fields, as their breeding habitat in the southern range began to disappear from anthropogenic habitat loss. In recent years, as shrublands revert to forests, GWWA continue to move north into Canada in search of new habitat. As global warming continues, northern climates like those in Canada might be more suitable for nesting neo-tropical passerines like GWWA, as well as other species acclimated to warmer weather. It is unknown how far north this species can keep moving until there is no habitat left.

This study was conducted in the Western Finger Lakes Region of New York, a previously unstudied area for the Golden-winged Warbler, and an important migratory route for many species of birds. Because of GWWA's role as a potential shrubland umbrella species, the habitat identified by this study could potentially be utilized for other declining species in the northeast such as American Woodcock (*Scolopax minor*), Ruffed Grouse (*Bonasa umbellus*), and New England cottontail (*Sylvilagus transitionalis*). By utilizing habitat requirements from the literature review, a habitat suitability model can be created for most species of conservation concern in this region, not just GWWA. The principle methods used are the same, making the concept of this model a powerful conservation tool for future habitat management studies here and abroad.

The concentration of identified Prime Habitat I and II sites are located in areas within the central counties of the AOI, collectively referred to as the Central Band. Although the prime

habitat concentrates in this area, the model shows multiple habitat sites throughout the AOI that ranged in size. 70% of the Prime Habitat I Sites are between 1.7 ha - 6 ha, which represent a typical range for GWWA breeding territory size, whereas of the highest concentration of Prime Habitat II Sites were 13-14 hectares (22 sites), representing a larger home range area outside of the breeding territory the species may utilize. The range in size of these sites offers locations that could be useful for larger broad scale habitat management (Prime Habitat II Sites), as well as smaller scale management (Prime Habitat I Sites), which are easier to manage and obtain for conservation agencies.

Breeding Bird Survey data were effective in validating the model results, where two-thirds of the routes that detected GWWA in the last five years contained prime habitat sites. BBS Route #61052 in Livingston County contained the most Prime Habitat I and II sites within a single route that has reported GWWA. 60-80% of the BBS routes that did not detect GWWA within the last five years had Prime Habitat I and II Sites, sometimes both being present in the same route, suggesting that future BBS surveyors will likely detect Golden-winged Warbler along these routes. BBS routes #6110 and #61050 in Ontario County contained the largest number of Prime Habitat I and II sites within a single BBS route.

For broad scale validation, Cornell Lab of Ornithology's eBird data were less effective because of a lack of eBird reports from sparsely human populated areas, where most of the GWWA habitat was contained. Current eBird initiatives, such as Avicaching, should help increase data in under-reported areas, which could make future use of eBird data more practical in presence/absence studies of rare and uncommon bird species.

Analyses of public land/managed parcel's showed prime habitat sites within managed lands, specifically concentrated within NYSDEC properties. It is hoped that NYSDEC utilize

prime habitat site locations that are within Wildlife Management Areas (WMAs), to aid in the GWWA conservation plans like the Young Tree Initiative. In WMAs like the High Tor WMA and the Rattlesnake Hill WMA, implementing this initiative would be most beneficial because of the concentration of prime habitat sites contained within, and because areas within these WMAs are already being monitored by the BBS.

Currently, GWWA breeding habitat is decreasing and/or is gone in other parts of their range, and continues to decrease as global warming and human development increases, leaving the responsibility for habitat management with land stewards and conservationists. This study identified ample amounts of potential GWWA habitat within the Western Finger Lakes Region, for which the lakes, shrublands, and forests are important migratory route for many birds, not just GWWA. It is hoped that agencies like the Golden-winged Warbler Working Group, NYSDEC, United States Geological Survey (BBS), and other management agencies consider the findings of this study when looking for areas to implement conservation resources for the Golden-winged Warbler and other early successional species that utilize similar habitat.

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